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The Determination of the Lime Requirement of Soils in Association with Soil Surveys.

By J. A. Prescott, D.Sc. and C. G. Stephens, M.Sc.†*

The opportunity for the study of methods for determining the lime requirement of soils is relatively limited in Australia, the need for liming being restricted almost entirely to those regions of high rainfall with agricultural possibilities. Of these, the sugar-cane growing areas of Queensland and portions of Tasmania present the most numerous opportunities for a systematic study of the problem. During the course of soil surveys by the Division of Soils, the opportunity has been taken of assessing the lime status of such acid soils as have been encountered. This status has been determined by means of buffer curves constructed by titrating the soil with lime water, the aim being to facilitate such subsequent advisory work as should be attempted on the basis of the surveys.

The method employed in the Waite Institute laboratories since 1925 is essentially that of Veitch (1902) as originally outlined, with the addition of the determination of the hydrogen-ion concentration at each stage of the process. Several portions of 30 gms. of soil are evaporated in basins after the addition of distilled water and varying quantities of saturated lime water. One portion is evaporated with distilled water alone, and it is convenient for the total volume of water plus reagent to be identical in each case. Before and during evaporation, the mixture is thoroughly mixed by stirring. When dry, the treated soil is ground to pass a 1 mm. sieve, and the pH value determined by one of the standard methods.

In this way, the quantity of lime requisite to bring the soil to any desired pH value can be read off from the titration curves so constructed.

According to Veitch (1904), this method of evaporation gave the same result as air-drying. The technique, however, was eventually abandoned by American workers in favour of methods not involving

* Chief, Division of Soils, C.S.I.R.
† An officer of the Division of Soils, C.S.I.R. Accommodated at the University of Tasmania.

evaporation, mainly on account of its tediousness, while, since the introduction of electrical methods for hydrogen-ion determination, the principle of the method has been further developed in such methods as those of Jensen (1924), and of Hissink (1925), who employs baryta instead of lime water. A direct titration of a single soil sample is employed by Hardy and Lewis (1929).

Where the sample of soil to be examined is a type sample from a survey, the evaporation technique is probably to be preferred in so far as it gives a dry end product in equilibrium with atmospheric conditions, and which can be readily handled as a normal soil sample.

Having established buffer curves for representative type samples, it has been found that certain general relationships can be developed which enable the lime requirement to be determined on other samples from a single value such as the pH of the soil, or from a pair of values such as the pH and the loss on ignition. An example of this latter is to be found in the King Island survey of Stephens and Hosking (1932). In addition, for these soils, there exists a good correlation between the loss on ignition and the buffer capacity between pH 6 and 7. This is a feature, if less definitely marked, for some other groups of soils with comparable texture, but the relationship does not hold for all such groups, as an examination of the figures for the basaltic soils (Tasmania) and the swamp soils of the lower Murray River (South Australia) will show (Fig. 1‡ and Table I.). A better correlation may have been obtained within the groups if more soils had been available. It would appear to be significant, at least in the case of podsolic soils, sands, and sandy loams. The relation of loss on ignition to buffer capacity between other pH ranges is illustrated in Fig. 2 for soils of various types. In the case of the swamp soils, for soils of less than 20 per cent. loss on ignition, a far better correlation is obtained between the initial pH value of the soil and the percentage of CaO required to raise the soil to pH 7. (Fig. 3). The same is true of the Frodsley soils, although in this case the evidence is not so exact (Fig. 4). The best instance, however, is given by the basaltic soils from north-west Tasmania, where an extremely close correlation is found between the initial pH value and the buffer capacity of the soil to any desired point such as pH 6, 6.5, or 7 (Fig. 5).

In Table I. are summarized the data used in the diagrams for a range of soils of different types from Tasmania and South Australia.

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‡ Soil No. 91 is omitted from Figs. 1 and 2, but lies in a position outside the limits of the diagrams and agrees with the correlation shown by the soils of its group.

Table I.—Lime Requirement Data for Various Soils.

Soil Number.	Loss on Ignition.	Initial pH.	Percentage CaO to Raise Soil to—				Percentage CaO Required Over the Range.			Soil Type.
			pH 4.	pH 5.	pH 6.	pH 7.	pH 4–5.	pH 5–6.	pH 6–7.	
University of Tasmania.										Various Tasmanian Soils.
162 ..	8·1	3·8	·015	·105	·212	·348	·090	·107	·136	Podsol
91 ..	75·6	3·9	·027	·340	1·160	2·270	·313	·820	1·110	Peat from Button Grass Plain
Longley ..	6·3	4·0	..	·037	·112	·228	·037	·075	·116	Podsol
84 ..	7·1	4·1	..	·033	·090	·180	..	·057	·090	Sandy peat from Button Grass Plain
160 ..	5·9	4·4	..	·075	·192	·309	..	·117	·117	Podsol (denuded)
28 ..	13·7	4·5	..	·032	·262	·551	..	·230	·289	Podsol
148 ..	4·5	4·7	..	·011	·065	·141	..	·054	·076	Podsol
93 ..	40·9	5·0	..	..	·340	·820	..	·340	·480	High moor soil
202 ..	9·1	5·2	..	..	·121	·329	..	..	·208	Podsol
151 ..	3·1	5·4	..	..	·017	·068	..	..	·051	Podsol
Lucaston ..	5·2	5·4	..	..	·027	·080	..	..	·053	Podsol
Ranelagh ..	3·2	5·8	..	..	·002	·030	..	..	·028	Podsol
145 ..	5·1	5·9	..	..	·003	·060	..	..	·057	Podsol
243 ..	10·1	5·9	..	..	·007	·150	..	..	·143	Brown loam
155 ..	8·4	6·1	..	..	..	·031	..	..	..	Brown loam
170 ..	4·3	6·2	..	..	..	·042	..	..	..	Podsol
250 ..	5·7	6·3	..	..	..	·075	..	..	..	Podsol
167 ..	5·4	6·4	..	..	..	·011	..	..	..	Brown alluvial soil
187 ..	10·4	6·5	..	..	..	·092	..	..	..	Brown alluvial soil
15 ..	25·1	5·1	..	..	·094	·368	..	..	·274	Basaltic soils from North-west Tasmania
11 ..	15·3	5·2	..	..	·088	·306	..	..	·218	
9 ..	21·3	5·2	..	..	·071	·213	..	..	·142	
5 ..	21·4	5·3	..	..	·062	·192	..	..	·130	
13 ..	20·6	5·5	..	..	·036	·180	..	..	·144	
7 ..	19·2	5·8	..	..	·007	·086	..	..	·079	
3 ..	14·4	5·9	..	..	·003	·101	..	..	·098	
1 ..	18·3	6·1	..	..	..	·031	..	..	..	
17 ..	15·3	6·2	..	..	..	·019	..	..	..	
Waite Institute.										Soils from Frodsley Estate, Tasmania.
3105 ..	10·4	4·8	..	·015	·115	·252	..	·100	·137	Black clay loam
3114 ..	4·4	4·8	..	·013	·075	·170	..	·062	·095	Podsol
3100 ..	10·9	5·2	..	..	·070	·187	..	..	·117	Grey brown loam
3108 ..	9·6	5·2	..	..	·056	·180	..	..	·124	Black clay loam
3123 ..	6·5	5·2	..	..	·088	·200	..	..	·112	Brown loam
3132 ..	5·6	5·2	..	..	·065	·168	..	..	·103	Grey brown sand (old river deposit)
3096 ..	5·4	5·3	..	..	·054	·175	..	..	·121	Podsol
3098 ..	6·8	5·3	..	..	·040	·125	..	..	·085	Grey brown loam
3138 ..	4·2	5·4	..	..	·040	·123	..	..	·083	Podsol
3117 ..	4·8	5·4	..	..	·040	·128	..	..	·088	Podsol
3111 ..	4·9	5·4	..	..	·038	·120	..	..	·082	Grey brown sand (old river deposit)
3103 ..	10·3	5·4	..	..	·021	·113	..	..	·092	Grey brown sand
3120 ..	6·6	5·5	..	..	·030	·120	..	..	·090	Podsol
3126 ..	8·7	5·5	..	..	·060	·205	..	..	·145	Podsol
3129 ..	6·7	5·8	..	..	·023	·126	..	..	·103	Grey brown sand (old river deposit)
1464A ..	13·7	3·9	·05	·28	·50	·78	·23	·22	·28	Swamp soils from the Lower Murray River, South Australia
1448 ..	14·8	3·9	..	·28	·47	·74	·28	·19	·27	
1131 ..	19·7	3·9	·05	·36	·62	·94	·31	·26	·32	
1425 ..	12·1	4·9	..	·01	·20	·46	..	·19	·26	
1080 ..	19·8	5·0	..	..	·24	·56	..	·24	·32	
1086 ..	16·0	5·3	..	..	·16	·32	..	..	·16	
1090 ..	29·1	5·3	..	..	·20	·53	..	..	·33	
1470A ..	15·1	5·6	..	..	·06	·27	..	..	·21	
1087 ..	9·4	5·9	..	..	·01	·20	..	..	·19	
1422 ..	18·1	6·0	..	..	..	·16	..	..	·16	
102 ..	1·9	5·9	..	..	·001	·033	..	..	·032	Mount Pleasant, South Australia

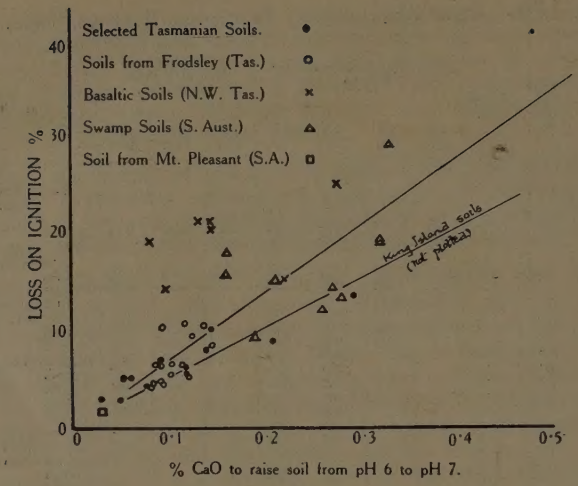

FIG. 1.—Relation between loss on ignition and buffer capacity.

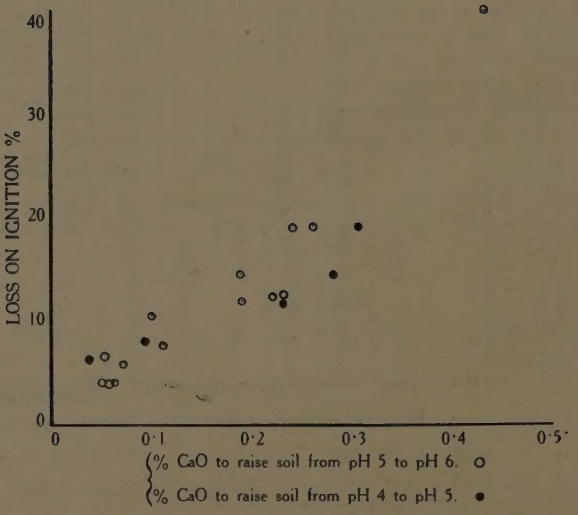

FIG. 2.—Relation between loss on ignition and buffer capacity.

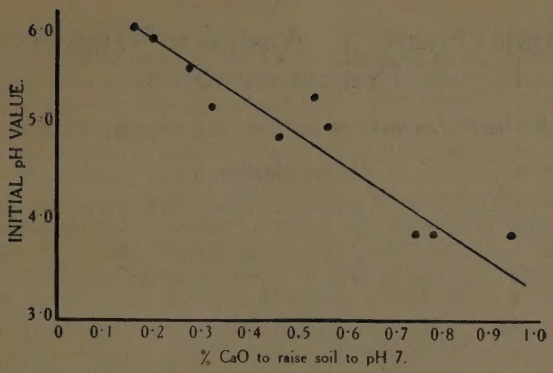

FIG. 3.—Relation between pH value and lime requirement of reclaimed swamp soils—Murray River, South Australia.

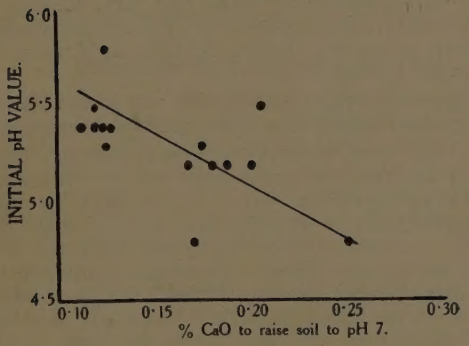

FIG. 4.—Relation between pH value and lime requirement of soils from Frodsley—Tasmania.

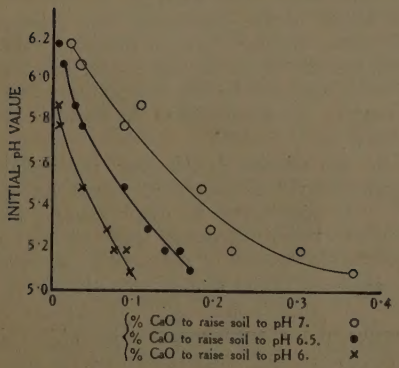

FIG. 5.—Relation between pH value and lime requirement of basaltic soils, N.W. Tasmania.

Brittle Heart in Australian Timbers: A Preliminary Study.

By H. E. Dadswell, M.Sc. and I. Langlands, B.E.E.†*

1. Introduction.

It is well known by Australian saw-millers and users of timber that the wood from near the centre of many trees cut commercially is extremely brittle and generally of low stregnth, with the result that this portion of the log is usually discarded in milling. This central brittle portion of the tree is known throughout Australia as the heart.

There appear to be two distinct forms (or stages) of heart:— (i) the obviously decayed central portion of over-mature trees, caused by "heart rots," and leading eventually to a hollow centre or "pipe," and (ii) an area of brittle wood often very difficult to distinguish from the neighbouring tough wood, and which may, or may not, be accompanied by visible heart rot. From the point of view of efficient utilization of the timber, the second form of heart is perhaps the more serious, as it occurs much more frequently than the first, and is usually difficult to detect with certainty.

This discussion deals particularly with the second form of heart, i.e., the brittle portion of the tree not obviously affected by decay.

In Australia, the term "heartwood," used overseas to describe the whole portion of the tree inside the sapwood, is often confused with heart—the brittle and valueless portion of the log. To overcome this difficulty, it was necessary to adopt a new word to describe the sound and commercially important wood extending from the brittle heart to the sapwood. In the "Draft Australian Standard Terms and Definitions Used in Timber Grading Rules" (7) issued by the Standards Association of Australia, the term "truewood" has been adopted to describe the wood from this portion of the tree.

In spite of the Australian-wide recognition of brittle heart, very little reference has been made to it in the published literature on Australian timbers. Robertson (5) referred to the brittle nature of the central wood of many of the eucalypts, and pointed out that it is more extensive in some species than in others. He associated it with the rapid growth of the trees during youth, and observed that it appeared to extend with age, but he did not know whether or not the effect was due to fungus; he emphasized the lack of scientific information on the subject.

Heart appears to be widely distributed throughout Australian timbers, but it is particularly extensive in numerous species of the genus *Eucalyptus*. It is also found in other genera, but it is not so well recognized in these, mainly because they are not so extensively used for purposes where strength is of primary importance.

The defect also appears to be widely distributed in tropical and sub-tropical timbers of other countries. Schneider (6) refers to "doty heart" occurring in the over-mature trees of certain Philippine timbers. Foxworthy (3), in his examination of the numerous genera belonging to the Dipterocarpaceae, records that, in addition to the

* Senior Wood Anatomist, Division of Forest Products, C.S.I.R.
† Timber Testing Officer, Division of Forest Products, C.S.I.R.

hollow centre and obvious heart rot occurring in the centre of large over-mature trees, in some of the red-wooded species of *Shorea* there is, surrounding the centre, an area of very brittle wood, which is of nearly the same colour as the neighbouring normal wood. Thomas and Walker (8, 9, 10, 11), investigating the mechanical properties of several Malayan species of the genus *Shorea,* found that brittle heart occurred in many of the trees, and up to 30 per cent. of the test specimens had to be rejected on account of this defect. In some species, numerous "felling marks" or "thunder shakes" (compression failures) were associated with this brittle heart or "sponginess." Howard (4) mentions that the centre of African mahogany is often soft and "spongy," and that "cross breaks" (compression failures) are frequent in this area.

Within the last two years, a considerable amount of work on the properties and nature of heart has been carried out by the Division of Forest Products during investigations of the mechanical and physical properties of a number of eucalypts, particularly *E. diversicolor, E. regnans, E. gigantea,* and *E. maculata,* the preliminary results of which are given in the present article.

2. Distribution of Heart within the Tree.

The change-over from very brittle to tough wood usually occurs within the space of an inch or so, but sometimes is very sudden, occurring within a small fraction of an inch. Plate 1, Fig. 1*, is a photograph of the cross bending fracture of a specimen of karri (*E. diversicolor*) showing a very sudden change from brittle to tough wood. The tension face is the nearest to the pith, and the brittle material shown is characteristic of heart.

Heart is usually more wide-spread towards the base of the tree, but the investigations showed that sometimes the area of brittle heart is most extensive in the upper portions of the tree. For example, in a tree of karri that was investigated, the extent of heart was at a maximum 60 feet from the ground. In all mature trees examined, brittle heart was found to extend for the full length of the merchantable bole. The area of brittle material is, in general, not concentric with the pith, and in vertical section the borderline between heart and truewood is usually irregular, so that at one particular point a certain growth ring may contain tough wood, whereas a foot or so further up or down the tree, the wood in the same growth ring and on the same side of the tree may be very brittle.

The experimental evidence indicates that heart extends with age. Twenty-one trees of young karri, ranging from 5 to 56 years of age, and from 4 inches to 22 inches diameter, were examined for the presence of heart, and although brittle wood was found near the pith of practically all the trees, in no case had it extended more than an inch or two from the pith. In medium to large sized trees (48 inches to 60 inches diameter) of the same species, heart occupied up to 20 per cent. of the cross-sectional area, and in a very large over-mature tree (76 inches diameter) more than 25 per cent., that is, more than half the diameter was heart. Forty trees of immature *E. regnans,* 15 to 25 years old and 4 inches to 22 inches diameter, were examined. Practically all showed signs of heart, but in no case had it extended

* See Plates facing page 248.

more than 2 inches from the pith, whereas, in older trees of this species, heart is very prevalent and extensive. It thus appears that heart, although present in most young trees, does not extend until the trees become quite large, and mature trees are more likely to be seriously affected by heart than younger and smaller trees.

3. Mechanical and Physical Properties of Heart.

The outstanding characteristic of heart is its brittleness and low impact strength. When broken in bending, the fracture is typically "carrotty," as distinct from the more fibrous fracture of the neighbouring truewood (see Plate 1, Fig. 2). The impact strength or toughness of heart is usually 50 per cent. or less of that of the adjacent truewood, and decreases still further towards the centre of the tree. The other mechanical properties (except perhaps the stiffness) do not appear to be greatly affected by the change from truewood to heart, at any rate, in *E. diversicolor*. Fig. 1 shows the variation, in a radial direction, of several of the mechanical properties of a typical karri tree. It will be seen that, within limits, there is a steady increase in all properties except toughness, with increasing distances from the pith. The point to be observed, however, is that there is no sudden change in the slope of the curves at the borderline of heart and truewood, or in other words, the comparatively low mechanical properties of heart appear to be due mainly to the inferior mechanical properties of wood from near the centre of the tree. Other tests, however, have shown that stiffness is definitely affected by the presence of heart, and that heart is less stiff than the adjacent truewood. Another interesting fact is that in heart the limit of proportionality in static bending is greatly lowered, and in some specimens of heart tested, the stress-strain curve showed no straight portion at all.

Although it has been previously stated that, with the exception of toughness and stiffness, the mechanical properties of karri are not greatly affected by heart, there is no doubt that when the heart is visibly affected by decay, all mechanical properties are much lower than can be accounted for by the normal reduction in the strength of the wood near the centre of the tree.

Although the density of heart is lower, on the average, than that of truewood, the difference is almost entirely due to the gradual reduction in density towards the centre of the tree, there being no sudden change in density at the change-over from heart to truewood.

Experiments have shown that, in general, heart collapses more than truewood. Apart from collapse, no information is available on the relative shrinkage of heart and truewood.

4. Structure of Heart.

Two interesting facts were noted during the physical examination of heart. In the first place, it was found that the material obtained from the maceration* of brittle heart contained a very large percentage of what may be termed "broken fibres" (see Plate 2, Fig. 1). There was often more than one break in any one individual fibre, and the breaks were at an angle of approximately 90° to the long axis of the fibre. In other words, the individual fibres showed the same distinct brittle cross breaks as the brittle heart itself. The macerated

* Maceration was carried out by the use of potassium chlorate and nitric acid.

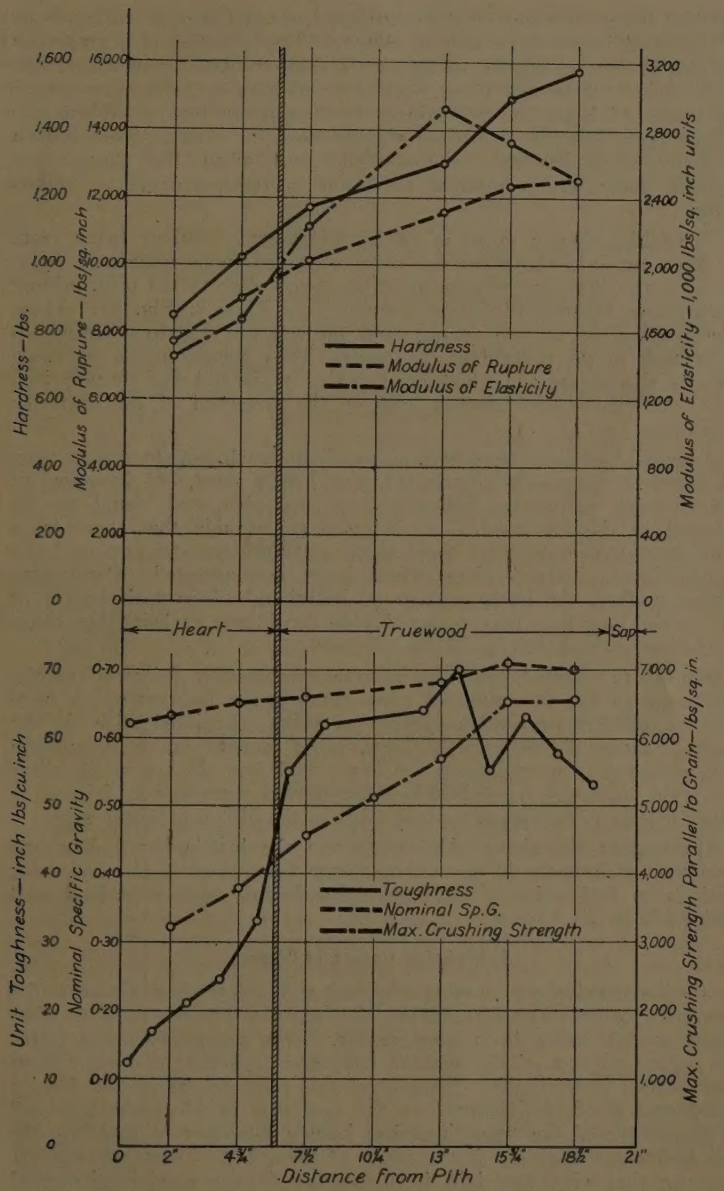

FIG 1.—Variation in mechanical properties from pith outwards of a typical log of karri (*E. diversicolor*) when green.

material from truewood, on the other hand, showed the natural elements of the wood in normal size and shape. Experiments with numerous samples of several species of eucalypts showed that, by means of the examination for broken fibres, it was possible to estimate very closely the limits of heart as determined by toughness tests. When the change from heart to truewood was sudden, the change from broken to sound fibres was also very marked; and when the change was gradual, there was a gradual variation in the percentge of broken fibres.

Secondly, when a series of radial microscopic sections taken from the pith out into the truewood were examined under polarized light, it was found that, in the area of brittle heart close to the pith, minute compression failures (1) were common (see Plate 2, Fig. 2). These microscopical or minute compression failures are due to a lining up of failures in the individual cell walls. They should not be confused with the slip planes (1) which are revealed in the cell wall by polarized light, and which are common even in the truewood of the majority of timbers.

In radial sections from several eucalypts, such minute compression failures were very numerous in the most brittle wood, but decreased in number with increasing distances from the pith, and could not be detected in the truewood. It is quite conceivable that there is a definite connexion between these minute compression failures and the broken fibres obtained when brittle heart is macerated. Continuing a step further, the large number of individual fibres with breaks at 90° to the long axis may reasonably be considered as being the cause of the carrotty or brittle failure of heart.

Bienfait (1) stated that the minute compression failures are the first stage in the formation of gross compression failures which have been recorded by several observers as being associated with brittle heart. However, in karri at least, gross compression failures have been observed to extend from the heart well into the truewood where the wood, although very brittle right at the compression failure. is tough within a fraction of an inch of it in the direction of the grain.

Apart from the above, the wood from the brittle heart shows no structural differences in general anatomy from that of the truewood, sections on both sides of the border line having been examined and compared.

5. Probable Causes of Heart.

In the eucalypts and other tropical and sub-tropical timbers, the tree often grows very fast during the early years of its life, after which growth slows down considerably. This fast-grown wood forms the centre portion of the mature tree, and is lower in density than that formed later in life. Because of this central core of low density fast-grown wood, and because of the fact that brittle heart is found at the centre of the tree, there has been a tendency to associate the two and to say that one is the cause of the other. Tests have shown, however, that when first laid down this low density wood is of normal toughness, and becomes brittle only later in life; in the older trees, the area of brittle heart extends far beyond the area of fast-grown, low density wood. It thus seems apparent that the onset of brittleness must be due to some external causes.

The fact that minute and gross compression failures are common in heart may suggest that heart is caused by mechanical stressing, such as compression due to the increasing weight of the tree as it grows or to internal stresses set up in the tree. However, a series of experiments in which compression failures were induced in green karri by short time loading revealed that the wood close to the gross compression failure remained as tough as that from unstressed matched samples. Thus, it appears that heart cannot be caused by short time mechanical stressing, and, by inference, it seems unlikely to be caused by long time loading, especially since the heart is sometimes more extensive higher up in the tree than at the butt, where the maximum stress may be expected.

From all the evidence available, the most satisfactory explanation of heart is incipient decay, which would account for the gradual extension with age, for the rather erratic distribution throughout the tree, and for the presence of visual decay at the centre of older trees. Incipient decay would also account for the observed variation in the various mechanical and physical properties.

To check this explanation, microscopic sections were prepared from pith into the truewood of all the test specimens mentioned above, and carefully examined by J. E. Cummins, Senior Preservation Officer of the Division of Forest Products, for the presence of fungus. The results to date indicate that fungal hyphae were present in all specimens of heart examined, but they were sometimes very difficult to detect. This aspect of the study of heart and the identification of the causal fungus or fungi is being continued by Mr. Cummins, and the detailed results will be published later.

Chemical analyses of karri heart and truewood are being carried out by W. E. Cohen, Senior Chemist of the Division of Forest Products, and preliminary results indicate that the ratio of Cross and Bevan cellulose to lignin is greater in heart than in truewood. Full analytical results will be published in due course.

6. Methods of Detection.

One of the most dangerous features of heart is the difficulty of detecting its full extent in a log, it being practically impossible to mark out the limits of heart by an inspection of the end section. Although sawmillers are usually careful to eliminate it as far as possible, they are not always successful in rejecting all of the brittle wood. While the amount that escapes detection may not prove a serious defect for such purposes as flooring, joinery, &c., it is a serious defect in stock to be used for such purposes as sporting goods and tool handles, where shock resistance is important, and also for telephone and telegraph cross arms and similar uses where considerable danger to life may be involved by sudden failure.

In converting the logs, the more severe heart can be detected by the appearance of the wood. Also, in sawing, heart cuts somewhat more easily than sound wood. Pieces of timber containing heart have a different "ring" when dropped than do those composed of sound wood.

A convenient and practical method of detecting heart in converted timber is to split off a small piece, say 3-16 inch or ¼ inch square and a few inches long, and then to break it in the fingers, observing the type of fracture—whether fibrous or brittle. After a little experience, heart can be detected with considerable accuracy by this method.

Another method which can be used is to raise the fibres of the wood with the point of a knife and to observe whether the fibres break easily and with a carrotty failure or whether they lift in long splinters. In applying this test, care must be taken not to confuse sloping or interlocked grain with heart, and the test should be carried out only on the tangential (back-sawn) faces of interlocked woods. While being of value for all green timber, this test is inapplicable to the harder species when dry, because of the difficulty in inserting the knife in the dry wood.

In the laboratory, more definite tests can be applied. As mentioned above, the maceration of the material with potassium chlorate and nitric acid separates the individual wood elements which may then be examined under the microscope. The presence of large numbers of broken fibres indicates heart with certainty, while the absence of them indicates truewood. It has been found in the few cases examined that if the wood is brittle from causes other than heart, broken fibres are not present.

Another laboratory test for brittle wood is the toughness or Izod test, in which the specimen is broken by the sudden application of the load from a falling pendulum, the amount of work absorbed in breaking it being noted.

For manufactured or semi-manufactured articles, such as cross arms, it is suggested that an impact proof test would be a rapid and certain method of eliminating pieces containing heart. It has previously been proposed to use static tests for this purpose, but these would not be satisfactory because of the comparatively high static strength of heart. If the static proof load were sufficiently high to eliminate all pieces containing heart, it would be liable to seriously damage some pieces of perfectly sound wood. On the other hand, the difference between the impact strength of heart and truewood is so great that an impact proof test that would reject all pieces containing heart without injuring those composed of sound wood could easily be devised.

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Fishery Research.*

Professor Dakin pointed out that fishery research is already a vast subject, although a comparatively new one, and thought it advisable at the outset of his remarks to try to clear up any misconceptions that might exist as to what fishery research is. Quite a lot was known about fish all over the world before any real fishery research began. Little research of this kind was accomplished before 1870, but volumes had been written on fish before that time.

A lack of knowledge of actual facts accounts for the very positive remarks made from time to time that Australia has the greatest fishing coast in the world. Australia's fisheries at the present time produce about 27,000 tons of fish per annum, worth about £1,100,000 per annum, and probably employ about 9,000 men. The degree of their possible expansion is quite unknown. Compared with these figures, the total value of the fish landed each year in Great Britain is somewhere about £20,000,000, and in Japan about £30,500,000. The North Sea alone (an area only about five times that of Tasmania) furnishes about 400,000 tons of herring each year.

Fisheries research began in an interesting way and about the same time, in several countries, and the cause was the general fear of depletion. All kinds of researches have been carried on under Government auspices, but on the whole such work has not been exploration for new fishing grounds. The British Government has assisted in this sort of work on two occasions of recent years, but only in a general way, by agreeing to share on these exploratory cruises certain losses which might arise, such as loss of gear, as a result of working on grounds which had never been tested before.

Germany was probably the first country to institute a definite Government committee to conduct fisheries investigations, and to ascertain whether depletion was occurring in the North Sea. This committee was appointed in 1870.

Almost at the same time, the United States passed a Bill, consequent on discussions as to depletion up and down their coasts. This was the beginning of the United States Bureau of Fisheries, which is the most famous institution of its kind in the world. Japan is now carrying on research work on an exceptionally large scale, but it is not so easy to get the fullest information in regard to it.

Compared with other types of biological investigation, fisheries research is difficult. The agriculturist, for instance, can watch the growth of the plants with which he is dealing, the veterinarian his animals, and so on, but the fisheries investigator has the whole picture obscured. Everything is behind a screen of dark water, on the surface of which it is not always propitious for him to be out. It is therefore not surprising that his progress has been slower than in most other branches of biology. Even so, he is beginning to know things, and what he has already done is so valuable that nations like the United States of America, England, and Japan continually spend more and more on this type of research, which is centred at such stations as those at Woods Hole, Plymouth, Heligoland, Naples, and Monaco.

* Notes of an address given by Professor W. J Dakin, Department of Zoology, University of Sydney, to a meeting of the New South Wales State Committee of the Council on 26th July, 1934.

One of the unexpected results of fishery research has been the discovery that the fish populations of the sea vary in a manner for which man's depredations are not responsible. These natural fluctuations may cause the success or failure of great fisheries. An important aspect of fisheries investigations is to endeavour to determine what it is that causes these natural fluctuations. The biologist has already found that fish are very sensitive to light, saltness of the water, and temperature. Quite recently, for example, it has been shown that the codfish can appreciate a rise of one-tenth of a degree in temperature, and in European seas it has long been believed that the catch of certain fish may be related to the temperature of the sea.

Professor Dakin visited Kiel in 1908, to study fisheries research there, and met practically all the early workers who formed the Kiel Commission in 1870.

The investigations carried on have developed, of recent years, into most elaborate statistical work in marine biology. For example, it has been possible, by the application of statistics to length measurements and scale examinations, to discover means for determining the age of fish. Scales show lines of growth, and the age of the fish can often be determined from these rings of growth. The other method utilizes the measurements of very large numbers of fish taken under certain definite conditions. Work in this direction is being done at Sydney University by Mr. Colefax. Upwards of 30,000 flathead were so measured, and when plotted out the resulting curves showed a number of peaks. Each peak probably represents the average length of fish of a certain year of age, and the difference between two successive peaks represents one year. However, a great deal more work would be necessary to interpret the data correctly.

Professor Dakin described and demonstrated the method employed for measuring the fish at sea, as a preliminary to plotting out the results later in the laboratory.

As a result of the statistics obtained by various Governments from similar measurements on a large scale carried out in the North Sea, the discovery was made that, when post-war trawling began, following the close period of several years imposed as an inevitable consequence of the war, the plaice caught were much larger than those caught before the war, and these large fish were more numerous. Investigations showed, however, that the growth of the post-war fish was probably slower than in the case of the pre-war specimens. One interpretation of this fact was the following:—The fish had been left undisturbed, and had grown to sizes seldom met with before. These large fish competed with the younger ones. The small fish growing up had therefore less chance of obtaining favorable conditions of food, &c., and their growth was restricted accordingly.

If this is true, it shows that the close season brought about by the war may not have been altogether productive in the fullest degree. It had resulted in a large number of big fish, but had slowed down the rate of fish flesh production. Governments have had to realize the difficulty, if not the impracticability, of instituting close seasons without more definite knowledge of the likely results. What is wanted is not a moderate number of big fish, but the quickest production of smaller, yet commercially valuable, fish. Thus the optimum condition may not be the natural condition of virgin fishing grounds.

The method of investigation by statistics is really the essential feature of all fishery investigations in the world to-day.

The fisheries of Australia, with the exception of trawling in New South Wales, are at present practically entirely fisheries of estuaries and inland waters. The greatest fishery in the world is the herring fishery, which is carried out on fish "schooling" away from the bottom in surface waters. Such fish (the pilchard and the mackerel are other species) are known as "pelagic" fish. Australia has no pelagic fishery; the drift net, or any other machinery for pelagic fishing of a commercial size, has never been really used in Australian waters. To give an idea of the extent of pelagic fishery, the total Californian fish production for 1929 was 857,000,000 lb., and of that amount 652,000,000 lb. were pilchards. The total Australian yield of all fish for 1931 was 63,000,000 lb.; in other words, about one-tenth of the Californian coast yield in pilchards alone.

One of the lines of research at Sydney University has been to investigate the plankton—that is, the floating life of the waters—outside the coast, and in the course of this work a considerable number of fish eggs of various kinds have been secured. It is still news to many fishermen that the eggs of nearly all food fishes (the herring is an exception) float on the surface of the sea—no matter whether the fish live on the bottom or in the surface or intermediate waters. In this investigation, the difficulty has been met with that a great deal of work is needed to be able to establish to what fish species the eggs belong. There are so many kinds of fish in New South Wales waters that work is particularly difficult here, and very rarely is it possible to obtain a clue from the egg, or even from the early stages of growth, as to which fish species the egg belongs. It has been possible by continued working week after week, to obtain larger growth stages of the fish hatched out from the eggs. Investigations on these lines in regard to pilchard eggs have been carried on for a period of four years. The breeding places of these fish have been found, and also the months when they are most abundant, and this discovery may be worth hundreds of pounds as information for guidance in commercial fishing. The Australian pilchard happens to be closer to the Mediterranean pilchard than any other in the world.

Professor Dakin here showed to members of the Committee samples of the eggs of the pilchard and anchovy.

Another line of research has been in connexion with prawn fishing. This is not so important an industry as some other branches of Australian fisheries, although it was worth to New South Wales in 1931, £21,000 more than the oyster industry. This investigation provided a big puzzle, the solution of which has been extremely interesting.

The biggest prawn fisheries in New South Wales are those of the lakes, for example, Tuggerah Lakes, Lake Illawarra, and of Port Jackson. Two of these lakes are big expanses of water, with in both cases very small entrances to the sea. From these lakes, prawns are to be seen during the summer of every year, going out to sea in large numbers. On a summer night at Lake Illawarra, when there is no moon, it is a very usual custom for visitors, equipped with a hurricane lamp, a tin, and a net, to go out at about 7 o'clock, and stand waiting

in a semi-circle touching each other right across the small channel to the sea. At first not a prawn will be seen, and then suddenly, like a flash, large prawns come in masses. Yet the fishermen at Lake Illawarra, some of whom had been fishing for even 40 or 50 years, were all emphatic that they had never seen prawns going into the lake, and were convinced that, as they went out in millions, they must breed in the lake.

The English shrimp and the European prawn carry their eggs under the abdomen, and the fishermen naturally looked for eggs in the same place on the Illawarra prawns, but could find none. As a matter of fact, the eggs of Australian prawns are shed straight from the ovaries into the sea. On this assumption, it was decided to examine the ovaries, and hundreds of prawns sent from the Lakes were opened at Sydney University, but no ovaries were developed in any of them. It was therefore obvious that the prawns did not breed in the lakes, as otherwise the only possible explanation of the failure to find breeding individuals was that the breeding prawns in some mysterious way managed to hide, and were never captured.

The first clue to the truth came from the fact that lake prawns were occasionally caught by the trawlers at sea. These prawns were exceptionally large, and, when they were opened, well-developed ovaries were found. Professor Dakin showed the meeting a very large prawn, and stated that many jokes had been made concerning its size. He said that every prawn had to reach such a size before it bred, and that breeding was carried out at sea. Later, young stages were discovered in the plankton nets, and they had been discovered at every stage, from the egg to the tiny prawn. The Illawarra and Tuggerah Lakes, and the Parramatta River are all supplied with prawns at these tiny stages—when less than half an inch in length. They grow up in the lakes, where food is plentiful, until they reach the age at which they are ready to breed, and then go out to sea. So far as is known, they never return, and may never breed again.

One or two puzzles still remained regarding the dimensions of the prawns. It looked as if the explanation might be that growth was very rapid, but the work had necessarily been on a small scale, and insufficient data could be obtained to establish this belief. Then the United States Government decided to investigate the life-history of their prawn, which has suddenly developed into an industry of very great value. Hearing of this investigation, Professor Dakin wrote to America, and received in reply a request for information regarding the Australian prawn. The American authorities stated that there was every indication that the full size of the prawn is reached from the egg in one year or thereabouts. This fits in absolutely with the work done in Australia.

Professor Dakin hoped that the above examples would give the committee some idea of the kind of work which he and his staff were carrying on. The examples are really only a brief indication of a science which has now become a special branch of biology. Its study needs a considerable amount of experience, which necessitates the proper training of men. If Australia intends to take up fishery research on any worth-while scale, it will be absolutely essential to obtain well-trained men for the work.

The Influence of Skin Wounds made during Shearing on the Incidence of Caseous Lymphadenitis in Sheep.

By L. B. Bull, D.V.Sc. and C. G. Dickinson, B.V.Sc.†*

Our knowledge of the factors associated with the infection of sheep by the Preisz-Nocard bacillus (*Corynebacterium ovis*) and with the production of the disease known generally as caseous lymphadenitis has been outlined in a previous publication,‡ in which a review of the literature was also given.

The present communication deals with some observations made in an attempt to obtain more definite information on the incidence of the disease as influenced by wounds received in the shearing-shed.

The evidence obtained by observations in the field and by experimentation has led workers in Australia and New Zealand to conclude that infection occurs in sheep through skin wounds, and that the wounding takes place most commonly during shearing operations. There were, however, no definite observations on the effect of keeping a group of animals entirely free from shear-made wounds, while being subjected in all other respects to the same conditions as the rest of the flock.

For the purpose of our experiment, we selected a flock from which the wethers are sent to slaughter at about three years of age. In the year 1931, a group of 45 male lambs (Group 1) was emasculated by crushing the spermatic cord with the Burdizzo instrument. The tails were left long. Subsequently, the animals were shorn each year very carefully with hand shears in the shearing-shed, but before any other sheep had passed through the shed. Any animal wounded by accident was removed from the group. In this way, the animals remaining in the group could be said never to have been wounded during shearing, but some wounding in the field from other causes could not be excluded. Throughout their lives the animals ran with the wethers of their own age, and in all respects (apart from shearing, tailing, and marking wounds) were subjected to the same conditions as the rest of the flock.

Another small group of animals (Group 2) from the same drop was tailed and marked in the ordinary way, and shorn by hand blades in the shed, for the first two years. Unfortunately, through a mistake, they were not shorn with blades at their third shearing, but were machine-shorn in the ordinary way. Thus the animals in Group 2 were treated in the same manner as the rest of the flock, with the exception of their being hand-shorn with blades for their first two shearings.

A number of three-year-old wethers from this same property had been examined in the slaughter-house during the last few years in order to obtain an approximate estimate of the caseous lymphadenitis incidence in the flock.

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* Deputy Chief, Division of Animal Health, C.S.I.R.

† An officer of the Division of Animal Health, C.S.I.R. accommodated at the Pathological and Bacteriological Laboratory of the Adelaide Hospital.

‡ Bull, L. B., and Dickinson, C. G., *J. Coun. Sci. Ind. Res.* (Aust.), **7**; 78, 1934.

Table I. gives the results of examinations after slaughter of the various groups:—

TABLE I.

Year.	Description.	Number Examined.	Number Affected.	Percentage Affected.
1931	Controls ..	133	39	29·3
1932	Controls {	16 old ewes	9	56·2
		6 wethers	1	16·6
1933	Controls ..	Nil	Nil	Nil
1934	Controls ..	147	44	29·9
1934	Group 1 ..	38	1	2·6
1934	Group 2 ..	23	7	30·4

With the exception of the 16 ewes in 1932, all the animals in the above table were three-year-old wethers.

All the affected animals showed involvement of the superficial lymph glands, but the lungs were also involved in up to two-fifths of the controls and of Group 2. The one animal affected in Group 1 had a small focus of infection in the right prescapular gland.

These results demonstrate clearly that, if animals are protected from skin injuries such as those received in the shearing-shed, the incidence of caseous lymphadenitis can be considerably reduced. They also suggest that skin injury and infection can take place in the field, leading to a small proportion of caseous lymphadenitis in a flock.

These observations confirm the conclusion already referred to, that caseous lymphadenitis results from infection of wounds. Although the shearing-shed is implicated, there is nothing in these observations to show whether the infection was contracted in the shearing-shed, as the result of contamination of the shears, or in some other way.

We wish to thank Mr. T. A. Burrage, Chief Inspector of the Adelaide abattoirs, for his assistance in the examination of the carcasses in these and other experiments.

Apple Investigations in Tasmania: Miscellaneous Notes.

By W. M. Carne and D. Martin, B.Sc.†*

1. The Virus Theory of Bitter Pit.

Many theories have been advanced to explain the origin of bitter pit. Smith (20), in 1926, published a useful review. In addition to those mentioned by him, there are theories by Herbert (10), Brooks Fisher (3), Valleau and Johnson (23), McLarty (14), and Carne, Pittman, and Elliott (5, 7). Some of these theories set out to explain only one, or a limited group, of the various disorders which have at one time or another been called bitter pit. Indeed, the authors in some cases have not regarded the disorders dealt with as bitter pit. Hardly two authors agree as to the definition of this trouble.

Of recent years, attempts made to confirm or refute the theories have been mainly confined to those of Carne and his colleagues in relation to storage pit, and to those of Mix, Brooks, and Fisher, and Carne, Pittman, and Elliott, in relation to drought spot, cork, crinkle, &c.

Quite recently, a new theory has been advanced by Atanasoff (1, 2) that bitter pit, used in the sense of covering all the defects mentioned above, is due to the infection of apple trees by one or more viruses. This theory has attracted some attention, possibly because of modern tendencies in pathology. Reference to the publications mentioned above, and to others by Rigg and Tiller (18), Fisher, Harley, and Brooks (8), and Wallace (24) will provide abundant evidence of the unsoundness of Atanasoff's conception of bitter pit, and many data which will not fit in with the theory of virus causation. For instance, it has been shown (8) that crinkle and water-core can be induced in susceptible varieties by directing the heat from an electric radiator on to the fruit while it is on the tree. Further, it has been the experience of one of us (6, 7) that water-core is necessary for the formation of crinkle, and that a tree affected with one or both may be free from both for several seasons before or after their occurrence. Many of Atanasoff's statements are contrary to our experience, notably that storage pit occurs only in fruit from trees which develop some pit in their fruit whilst on the tree.

Atanasoff has founded his theory mainly on selections from published data. Fortunately, he does give a simple method of experimentally testing the theory, and is himself putting it to the test. He states: ". . . this question could be settled definitely by repeating McAlpine's graft experiments." McAlpine sought to ascertain whether internal cork of pears could be conveyed to unaffected trees by grafting the latter with scions from affected trees, and vice versa.

Whilst on a visit to Tasmania in 1932, the senior writer's attention was drawn by Mr. P. H. Thomas, Senior Horticulturist, Department of Agriculture, to the occurrence of internal cork in apples (mainly Sturmer Pippin), and on a Gansell's Bergamot pear tree. In September, 1931, he had grafted scions of the pear tree on to an unaffected

* Senior Plant Pathologist, Division of Plant Industry, C.S.I.R., accommodated at the University of Tasmania, Hobart.
† Junior Plant Pathologist, Division of Plant Industry, C.S.I.R., accommodated at the University of Tasmania, Hobart.

tree in a different district. One particular Sturmer apple tree was so affected in its fruits and shoots that he published an article about it (21). The affected shoots illustrated in the article were used to graft two unaffected trees in another district, while scions from these trees were used to graft the affected tree. In each case, limbs were shortened and top-grafted, allowing the balance of each tree to fruit normally. These facts are stated in some detail, as Atanasoff quotes this article as giving evidence of symptoms of bitter pit other than those found in the fruit. It therefore follows that in the results with Sturmers given below, we are dealing with a case that Atanasoff recognizes as bitter pit. Since the winter of 1932, the trees concerned have been under frequent observation by us. In the table below, we give the results of Mr. Thomas's experiment, the results obtained by McAlpine, which Atanasoff uses as his main argument in favour of the virus theory, and also McAlpine's results given in the same place (13), which Atanasoff does not quote. It will be noted that the results provide evidence against, rather than for, the theory. This does not, of course, mean that some of the many disorders that Atanasoff recognizes as bitter pit are not due to virus infection. It does indicate, however, that his application of the theory to all is not justified.

INTERNAL CORK.—RECIPROCAL GRAFTING OF AFFECTED AND NON-AFFECTED TREES.

Locality.	Variety.	Graft-ed.	Condition.	1913.	1914.	1915.	1916.
			In Victoria.				
	Pear.						
Campbell's Creek	Josephine (trees 1 and 2)	1912	? Clean scion 2 on affected tree 1	*o*	*o*	*o*	*x*(1)
				?	?	?	*x*
			Affected scion 1 on ? clean tree 2	*o*	*x*	*o*	—
				—	*x*	—	—
	Winter Nelis (trees 3 and 4)	1912	Clean scion 4 on affected tree 3	*o*	*o*	*o*	—
				?	?	?	*x* slight
			Affected scion 3 on clean tree 4	*o*	*o*	*o*	*o*
				—	—	—	—
			In Tasmania.				
	Pear.			1931.	1932.	1933.	1934.
Kettering	Autumn Bergamot A	1931	Affected scion B on clean tree A	*o*	*o*	*o*	*o*
				—	—	—	—
Bagdad	Gansell's Bergamot B	1931	Clean scion A top-grafted on same branch as B above	*o*	*o*	*o*	—
	Apple.						
Grove ..	Sturmer C ..	1931	Affected scion C on clean tree D	*o*	*o*	*o*	—
				—	—	—	—
Margate	Sturmer D ..	1931	Clean scion D on affected tree C	*o*	*o*	*o*	*x*
				x	*x*	—	*x*

o = no fruit set. ? = no data. *x* = fruit affected. — = fruit not affected.

(1) McAlpine states (5th Rept., p. 55) the tree from which graft was taken had 69 per cent. pit in 1914; therefore the result is of no value.

2. Crinkle in Apples.

Crinkle is one of several non-parasitic disorders of apples known as cork. Characteristically it is only developed in half-grown, or larger, but still very immature, apples during mid-summer. In Tasmania and the southern half of Australia, the critical period is usually January and the early half of February. In very early varieties, such as Worcester Pearmain, it may develop in December. The writers have no knowledge of its occurrence in Queensland. Several forms have been noted by us.

1. The usual form is recognized by extensive depressions at the calyx end and forming a continuous or broken band around, or partly around, the fruit. The banded depression may be smooth or corrugated. Internally, necrotic lesions beneath the depression form a more or less continuous shallow layer below the skin, and they frequently develop cavities. This is the usual form on Rome Beauty, London Pippin, Dunns, French Crab, &c.
2. The surface depressions and internal lesions are not confluent, and are irregular in shape and distribution, though mainly in the calyx half of the fruit. This type is more characteristic of Democrat (Tasma) and Jonathan.
3. The whole or greater part of the surface is pitted and corrugated with a very shallow necrotic layer beneath. This form is apparently rare, and has only been seen on Dunns and Yates in Western Australia.
4. In Worcester Pearmain, in Tasmania, the constricted calyx end becomes further constricted usually on one side. Irregular pit-like lesions occur under this depression, but their extent is relatively small.

In all the above, the skin appears normal, at least at first. In form 2, it usually becomes involved, and dies, becoming dark and suggesting the spots of blotchy cork. Forms 2 to 4 do not appear to have been previously described.

All investigators of crinkle have noted its frequent association with that injection of the tissues known as water-core or glassiness (3, 6, 7, 8, 18, 24, 25). They are also in agreement that its occurrence is associated with conditions of severe atmospheric dryness. Investigators of water-core (4, 7, 8, 16) also agree that the same conditions of heat and atmospheric dryness are important factors in the cause of that disease.

The object of the present note is to provide further evidence in support of the conclusion arrived at by the senior writer and his colleagues in Western Australia, that water-core is not only associated with crinkle, but is an essential step in its origin (6, 7). This view does not appear to have received the attention of other workers. The writers are so convinced of its accuracy that they regard the association of water-core with cork lesions in apples about half-grown or larger as definite evidence that the lesions are those of crinkle. The failure to find water-core, especially late in the season, is no evidence that it has not been present. Experience has shown that water-core present when crinkle was first noted on a tree in January may not be recognizable in crinkled fruit examined in March, even when it had been externally evident at the earlier date. The only satisfactory way of determining the association is to start examining very susceptible varieties about ten days

after a period of high temperature and low humidity, watching for external evidence of both water-core and crinkle. Experience in Western Australia, and during the 1933-34 season in Tasmania has shown that it is possible to predict with reasonable accuracy the occurrence of visible crinkle in the more susceptible varieties 10 to 14 days after a heat wave in January or February. The severity of the occurrence on susceptible trees varies with the contrast between the condition during the heat wave and those preceding and following, rather than with the actual temperatures and humidity percentages recorded. Susceptibility is greatest in varieties most subject to water-core of the early or immaturity type (7), which involves the core, and more or less of the cortex, especially at the calyx end. It is greater in large than small fruits of the same tree, in light crops than heavy, and in exposed situations than in sheltered.

The development of crinkle has been traced from a condition of water-core in which the injected area reaches to, or very near to, the skin (known as watery-nose in Tasmania). The first stage is the browning of the injected tissues close to the skin. This browned area dies, and commences to dry out. Cavities form in the dead tissue, and the overlying surface of the apple collapses inward. By March or April, the injected area, which has been steadily contracting inward, may survive only in isolated patches around vasculars, or may have entirely disappeared. In some varieties, particularly Democrat, tissues adjacent to, or remote from, the injected areas may develop cork lesions before they develop in the outer portion of the injected tissue. This results in symptoms of the second type. Symptoms of the third type follow an unusual type of water-core noted following exceptionally severe heat-waves in Western Australia. The water-core in this case develops as a very shallow layer, 2 to 3 mm. deep, just beneath the skin. In the cases noted, the whole of the injected tissue became involved eventually in the crinkle.

Apparent exceptions to the association of water-core and crinkle have been recorded by one of us in Yates and Cleopatra (7), varieties then considered immune to water-core. It has since been found that, on rare occasions, both are subject to water-core and to crinkle. Water-core was not noted in association with the fourth type of crinkle occurring on Worcester Pearmain in 1932-33 season, but was found in the next season as late as mid-January. There appears to be a very definite association between the stage of maturity and crinkle. Worcester, the earliest export variety grown in Tasmania, was more affected in 1932-33 than in 1933-34, while the reverse was the case with the later varieties. In the former season, only one small heat wave occurred, in the early half of December. In the later season, there was again only one heat wave, a severe one, in the early part of February. The following data relate to this heat wave.

The humidity figures given above were recorded by a hair hygrometer, and the lower readings are probably too low. On the 8th and 9th February, severe bush fires developed. Trees and fruit were scorched, but more loss occurred from the dropping of pears and some of the earlier apple varieties. Experience in Western Australia made it seem very probable that severe water-core and crinkle would develop in some of the susceptible varieties. By the 19th February, both were found in severe form in French Crab, and to a lesser extent in Scarlet Nonpareil, Democrat, Cox's Orange Pippin, and Sturmer Pippin.

Brooks, Harley, and Fisher have experimentally demonstrated(8) that more drastic conditions are necessary to develop crinkle than water-core. Experience in Australia indicates that a severe heat wave of several days causes crinkle to follow on after water-core so closely that the two apparently originate together. Crinkle may, however, develop after a heat wave in fruit which previously had water-core.

Climatological Data, Huonville, Huon Valley, Tasmania, February 6th to 10th, 1934.

1934.	Mean Temperature.	Maximum Temperature.	Temperature Range.	Minimum % Humidity.	Hours Below 50% Humidity.	% Humidity Range.	Rainfall Inches.
	°F.	°F.	°F.				
February 6 ..	53·0	56·8	6·0	32	6	64	0·03
7 ..	62·3	81·5	38·4	4	6	92	..
8 ..	71·5	94·3	45·6	9	12	86	..
9 ..	78·5	99·4	41·9	3	9	92	..
10 ..	56·3	63·5	14·3	62	...	32	..

Varieties particularly subject to both early (immaturity) water-core and crinkle in Australia include Stone Pippin, London Pippin, Dunns, French Crab, Rome Beauty, and Democrat. Varieties which are more subject to late (maturity) water-core are less susceptible to crinkle. They include Cox's Orange Pippin, Jonathan, King David, and Delicious. Both water-core and crinkle have been recorded in Rome Beauty and North-western Greening in North America, and in Rome Beauty in South Africa. Both have been recorded on Bramley's Seedling and Rival in England. The following have been recorded as having crinkle, without mention of water-core:—In Australia, Annie Elizabeth, Newton Wonder, and Spitzenberg; and in England, Newton Wonder and Allington Pippin.

In addition to those mentioned, the following varieties have been noted by the writers as occasionally affected with both disorders:—Lord Wolseley, Granny Smith, Yellow Bellflower, Northern Spy, Rokewood, Statesman, Devonshire Quartredon, Ben Davis, Commerce, and Irish Peach.

3. Water-core Breakdown.

In 1930, attention was drawn (6) to the importance of water-core as a cause of breakdown in apples, particularly in certain varieties. Though this association has long been recognized in Canada and the United States of America, its importance in relation to apples for export has been neglected in Australia. Further evidence of the need of attention to water-core in the picking and inspection of apples for export is now brought forward.

Perhaps the most striking recent evidence is that given by Palmer(17), who, after seven years' work on Jonathan breakdown in British Columbia, has come to the conclusion that "there is strong evidence that breakdown seldom, if ever, develops in Jonathans which do not show water-core at harvest time."

Since the article referred to in the opening sentence was written, the senior writer and his colleagues in Western Australia and Tasmania have made a special point of looking for the association of water-core with other disorders of apples. The observations have been made in Western Australia, South Australia, Victoria, and Tasmania, and also in Australian apples in England during the export season of 1931. The following occurrences have been noted:—

Water-core in association with breakdown in apples still on the tree.—In Jonathan, Cox's Orange Pippin, Ribston Pippin, Irish Peach, and Cleopatra.

Water-core in association with breakdown in apples held in cool stores, sheds, &c.—In Jonathan, King David, Delicious, Cox's O. P., Ribston Pippin, London Pippin, Sturmer Pippin, Gravenstein, Dunns, Rokewood, Granny Smith, Stone Pippin, Statesman, Rome Beauty, Pioneer, French Crab, Yates, &c.

Water-core in association with breakdown in Australian apples in England. In Jonathan, Cox's, Rokewood, Rome Beauty, Dunns, &c.

Storage trials have also been made with apples of several varieties which were known to be more or less affected with water-core, in addition to those with Jonathan mentioned in the earlier article.

Delicious Apples with Water-core, Tasmania, 1932-1934.

Orchard 1.—Two cases rejected for export to the mainland on the ground of excessive water-core, the majority of the fruits examined being affected. Fruit made available by courtesy of Department of Agriculture. Stored the 5th May for 10 weeks at 32-34°.

Size (inches).	18 Days After Cool Storage.	
	Percentage Breakdown.	Percentage Other Waste.
2½	23	5
2¾	20	9

Orchard 1.—Two cases 2¼-in. fruit, approximately 20 per cent. with radial water-core. Stored 27th May, 1933, for 11 weeks at 31-34° and 38-40°.

After Cool Storage.	31–34°.		38–40°.	
	Percentage Breakdown.	Percentage Rots.	Percentage Breakdown.	Percentage Rots.
4 days	3	3	7	3
21 „	3	11	9	12

Orchard 2.—Four cases 2¾-3-in. fruit, approximately 100 per cent. with radial water-core. Stored 6th May, 1933, for 12-14 weeks at two temperatures.

After Cool Storage.	31–34°.		38–40°.	
	Percentage Breakdown.	Percentage Rots.	Percentage Breakdown.	Percentage Rots.
5 days	20	2	9	..
21 „	41	2	38	5

Orchard 3.—One case 2¼-2¾-in. fruit, approximately 70 per cent. with radial water-core. Stored 19th May, 1933, for 10 weeks at 38-40°.

After Cool Storage.	Percentage Breakdown.	Percentage Rots.
4 days	4	4
21 „	7	13

Orchard 4.—Eight cases fruit, approximately 100 per cent. with radial water-core. Stored 2nd May, 1934, for 10 weeks at two temperatures.

After Cool Storage.	31–34°.					38–40°.				
	Percentage Breakdown.			Percentage Mouldy Core.	Percentage Rots.	Percentage Breakdown.			Percentage Mouldy Core.	Percentage Rots.
Size (inches)	2¼	2½	2¾	..	..	2¼	2½	2¾	..	..
2 days ..	9	22	25	..	..	21	33	60	..	..
21 „ ..	15	32	42	1	7	24	44	70	1	7

Rokewood Apples with Water-core, Western Australia, 1930.

Six cases 2¾-in. fruit from a commercial line packed for storage. Approximately 50 per cent. affected with early water-core. Stored 6th June, 1930, at 32-34°. Two cases withdrawn from store 6, 12, and 17 weeks later.

Stored.	Ex Store.		Two Weeks Later.	
	Percentage Breakdown.	Percentage Rots.	Percentage Breakdown.	Percentage Rots.
6 weeks	1	..	9	2
12 „	1	1	6	8
17 „	2	6	8	16

French Crab Apples with Water-core, Tasmania, 1933-34.

Orchard 5.—Two cases 3-in. fruit from a commercial line, approximately 100 per cent. with early water-core. Stored 11th May, 1933, for 22 weeks at two temperatures.

After Storage.	31–34°.				38–40°.			
	Percentage Breakdown.	Percentage Rots.	Percentage Fleck.	Percentage Sound.	Percentage Breakdown.	Percentage Rots.	Percentage Fleck.	Percentage Sound.
3 days	42	1	..	..	2	30	..	..
20 „	87	1	2	12	2	53	77	4

Orchard 5.—Four cases of an export line with water-core to an unknown extent. Crop from which fruit taken known to be affected with water-core. Stored 24th May, 1934, for 10 weeks at two temperatures.

After Storage.	31–34°.			38–40°.		
	Percentage Breakdown.		Percentage Rots.	Percentage Breakdown.		Percentage Rots.
Size (inches) ..	2½	2¾	..	2½	2¾	..
1 day ..	6	9	..	15	22	..
21 „ ..	11	22	3	26	37	3

Stone Pippin Apples with Water-core, Tasmania, 1932-33.

Thirty-seven apples of various sizes with visible water-core. Stored 17th April, 1932, for 13 weeks at 32-34°. Fruit made available by courtesy of Department of Agriculture.

After Cool Storage.	Percentage Breakdown.	Percentage Rots.
1 day	3	10
7 days	43	10
14 „	70	14

This experiment was repeated in 1933 with a larger number of fruit, and with a similar result.

In the above results, rots have been recorded only on apples not affected with breakdown.

Water-core breakdown takes three general forms which are related to the types of water-core. There are two main types of water-core.

(i.) *Early or Immaturity Water-core.*—This form develops in immature apples, mainly of the harder varieties. It appears normally in January or February, or occasionally earlier, and most seriously after severe heat waves. Large fruits of light crops on trees in situations exposed to hot winds and long hours

of sunlight are particularly susceptible. Among the main commercial varieties, the following are susceptible:—Stone Pippin, French Crab, Rome Beauty, London Pippin, Dunns, Democrat, Rokewood, and Granny Smith. It is characterized by more or less extensive areas of injected tissue involving at least part of the core, and usually the cortex, mainly at the calyx end. In severe cases, the injection extends to, and involves, the skin. Small drops of a sweet exudate may appear on the visibly affected areas of the skin. With the onset of cooler weather from March on, the injected tissues of fruit still attached to the tree tend to regain apparent normality slowly. The last traces of water-core are usually found associated with the vasculars of the core-line. In this condition, it may be easily mistaken for the second type of water-core. However, it is frequently possible to recognize the tissues which have lost their injection, as the flesh is not quite normal in appearance. If the fruit is picked while still injected, its storage capacity depends upon the variety and the severity of the water-core. The slower ripening the variety the less is it likely to develop the breakdown or rots to which affected fruits are liable. We have found, however, that the loss of water-core in stored fruits and their apparent return to normal storage capacity is sometimes deceptive, especially if the fruit is on the mature side when picked. The apparently sound fruit when cut is sometimes found to be affected with numerous small light-brown lesions through the flesh, suggesting bitter-pit. The lesions, however, are smaller, lighter in colour, and do not show on the surface as in pit. We distinguish it as "fleck." In the storage test with French Crab in 1933, given above, the breakdown at the lower temperature was replaced by fleck at the higher. Fleck has also been noted in Democrats which have lost their water-core whilst attached to the tree.

(ii.) *Radial, Late, or Maturity Water-core.*—This type develops mainly in the softer and earlier varieties as they approach maturity. Varying with the ripening periods of the varieties, it usually appears in January (as in Gravenstein) to March or April (as in Delicious). In North America, evidence of its occurrence is regarded as an indication that susceptible varieties should be picked immediately. Important susceptible varieties include Jonathan, Delicious, King David, Gravenstein, Cox's Orange Pippin, Ribston Pippin, &c. Such varieties do occasionally suffer from the early type of breakdown or intermediate forms. In radial water-core, the core is not involved, and the injection is associated with the main vasculars of the core-line and the flesh between the core and the calyx. There are no external indications of its presence. If cut transversely, an affected apple will show narrow bands of injected tissue radiating from some or all of the main vasculars of the core-line. Apples with this type of water-core tend to get more affected as they ripen on the tree. If picked, the water-core slowly disappears, but the ability of the fruit to return to normality is much less than in the harder varieties affected with early water-core. In other words, they have a greater tendency to develop breakdown or rots.

With both types of water-core, low storage temperatures usually give better results than higher; the onset of breakdown is delayed, and the number of apples affected is usually less. The wastage from breakdown is least, and the recovery from water-core greatest in fruit kept under packing shed conditions. The danger of wilting and over-ripeness limits the time fruit can be held out of cool store.

Though varietal differences and intermediate stages occur, there are three main types of water-core breakdown.

(i.) *Radial Water-core Breakdown.*—This is the type known also as Jonathan, Mealy, Senescent, and Inherent Breakdown. An indefinite light browning, becoming darker and more defined, starts at or near the core-line, at first adjacent to, and later involving, the injected tissues. The browning spreads outward and inward until the whole fruit is affected, including the core. The injected tissues become dark, and may for some time be recognized, as they remain firm in contrast to mealiness of the other affected tissues.

The alternative names for this breakdown are hardly appropriate. It is not confined to Jonathan; neither is it the only breakdown affecting that variety. Mealiness is not confined to this type of breakdown. It is also not more related to maturity or to predisposing conditions than is low temperature breakdown.

(ii.) *Breakdown of the Deep Scald Type.*—In apples affected with early water-core, breakdown may commence not in, or adjacent to, the injected tissues, but at some distance from them. As the injection tends to be concentrated at the calyx end, the breakdown starts in the stem half. As the affected tissues dry out, the surface collapses, forming a sunken belt around the fruit. Though less defined, this belt strongly suggests deep scald or crinkle at the wrong end of the fruit. If the water-core is to one side of the fruit, the breakdown may develop either on the other side or around the injected area. In both cases, collapse follows while the water-core disappears internally, though the skin above retains the appearance of injection.

This type of breakdown we have noted in Stone Pippin, Dunns, and Rokewood. It does not appear to have been previously described.

(iii.) *Early Water-core Type.*—This type varies somewhat. It may at times develop actually in the injected tissues, in which case it is distinguished from ordinary water-core only by the brown colour. This browning is slow to develop, and it is almost invariably preceded by breakdown in the tissues which have lost their injection. It differs from the radial water-core type in that it does not usually start near the core-line. The core is also less frequently affected. The affected tissues do not become as dry and mealy. The skin becomes dark and injected, but not sunken. This form has been noted in many varieties, and particularly in French Crab, in Tasmania, in 1934.

4. The Correlation of Refractive Index and Freezing Point Depression.

In connexion with the chemical examination of experimental fruit used in the investigations, it was thought desirable to have some rapid, simple method of determining the molecular concentration of apple juice, and one which would also require only a very small quantity. By this means, it was hoped to demonstrate differences in sap concentration, and therefore the mechanism for possible osmotic gradients between the apple tisues.

The refractometer has been used successfully for the analysis of other plant juices (19, 22). Therefore, seven varieties of apples at different stages of maturity, and from an area of about 5 acres of fairly uniform soil type, were examined to see if any correlation existed between refractive index and molecular concentration and osmotic pressure.

Refractive index was measured by means of a Zeiss dipping refractometer with an auxiliary prism, and molecular concentration and osmotic pressure calculated from the depression of the freezing point determined by the Beckmann apparatus. The osmotic pressure may be calculated directly from $\triangle$ by Lewis's formula (9).

$$P\ 12{\cdot}06\ \triangle - 0{\cdot}021\ \triangle^2$$

or the molecular concentration calculated from $\triangle$ and the osmotic pressure read from the table drawn up by Molz (15).

For convenience, the osmotic pressure has been plotted against the eyepiece reading, which may readily be translated into refractive index from the table provided with the instrument.

A close correlation was found to exist, and for all the varieties examined (with the exception of Cox's Orange Pippin) may be expressed approximately by the straight line—

$$Y = \frac{10\ \text{atm.}}{0{\cdot}01112\ n_D} \cdot X - 4{\cdot}5\ \text{atm.}$$

When,

Y = osmotic pressure in atmospheres.
X = refractive index.
$0{\cdot}01112 n_D$ = 30 divisions of the eyepiece scale.

The graph for Cox's Orange Pippin is approximately:—

$$Y = \frac{11{\cdot}5\ \text{atm.}}{0{\cdot}01112 n_D} \cdot X - 9{\cdot}0\ \text{atm.}$$

When refractive index is plotted against molecular concentration, straight lines are also obtained, approximating to—

$$Y = \frac{0{\cdot}32\ M}{0{\cdot}01112 n_D} \cdot X - 0{\cdot}09\ M.$$

and for Cox's Orange Pippin—

$$Y = \frac{0{\cdot}32\ M}{0{\cdot}01112 n_D} \cdot X - 0{\cdot}13\ M.$$

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Scientific Papers from the Division of Economic Entomology published elsewhere than in the Council's Publications.

In a previous issue (5: 184, 1932) an article appeared discussing scientific papers for which officers of the Council's Division of Economic Entomology were responsible, but which had been published elsewhere than in the Council's publications. The article that follows brings the former list of such publications up to date. It will be seen that the various papers are concerned in general with scientific aspects of the problems such as that of the blowfly, of the buffalo-fly, &c., which the Council is investigating.—Ed.

Currie, G. A., 1932.—Oviposition Stimuli of the Burr-seed Fly *Euaresta aequalis* Loew. (Dipt. Trypetidae). *Bull. Ent. Res.*, vol. xxiii., pt. 2, pp. 191-193, 1 pl.

Mature females of the burr-seed fly (which is being tried in Australia in an effort to control Noogoora burr) tried to oviposit on artificial burrs made of rubber and hooked pins if placed on them and no natural burrs were present. The stimuli actuating the fly under natural conditions when ready to oviposit appeared to be:—

(1) The characteristic odour of *Xanthium* plants which attracted the flies on to their proper hosts.

(2) The shape of the fruit and the hooked spine on the surface gave the immediate stimulus for oviposition.

(3) The capsule structure allowed the passage of the egg when penetration by the ovipositor had been secured.

Currie, G. A., 1932.—Some Notes on the Biology and Morphology of the Immature Stages of *Harpobittacus tillyardi* (Order Mecoptera). *Proc. Lin. Soc. N.S.W.*, vol. lvii., pts. 3-4, pp. 116-122.

All larval stages (hitherto unknown) of this primitive insect are described and illustrated. The larvae are caterpillar-like, and have curious, large, fleshy tubercles on the dorsum and pleura of each segment. They are carrion-feeding in all stages, and have a habit of charging the gut with soil before moulting. After moulting, the soil is discharged all over the back and sides, and adheres thereto by virtue of a glutinous fluid added while in the gut. The larvae are then very difficult to distinguish from their surroundings. They can live only in damp situations, moisture being also necessary for the development of the embryo in the egg before hatching.

Evans, A. C., 1933.—Comparative Observations on the Morphology and Biology of some Hymenopterous Parasites of Carrion-Infesting Diptera. *Bull. Ent. Res.*, vol. xxiv., pt. 3, pp. 385-405, Sept., 1933.

This paper records some of the results obtained in the course of the Council's blowfly investigations in France. Four species were studied: *Aphaereta minuta* Nees, *Alysia manducator*

Pantzer, *Aspilota nervosa* Hal., and *Mormoniella vitripennis* Walk. *Asp. nervosa* was parasitic on a Phorid, *Apiochaeta* sp., and the other species attacked blowflies. *Aph. minuta* parasitises young larvae, *Asp. nervosa* half-grown larvae, *Al. manducator* full-grown larvae, and *M. vitripennis* puparia. The biology, life histories, and morphology of the parasites are described. The progressive degrees of adaptation to endoparasitic life of the three Alysiines are discussed with special reference to amount of growth in the egg stage, reduction of head capsule and mouth parts, loss of locomotor organs, and reduction of the tracheal respiratory system.

Evans, J. W., 1933.—A Simple Method of Collecting Thrips and Other Insects from Blossom. *Bull. Ent. Res.,* vol. xxiv., pt. 3, pp. 349-350.

A description and illustration are given of a glass cylinder adapted for the rapid collection of thrips from blossom.

Evans, J. W., 1933.—A Revision of the Eurymelini (Homoptera Bythoscapidae). *Trans. Royal Soc. S. Aust.,* vol. lvii., pp. 73-90.

This is a revision of the tribe Eurymelini containing a key to the genera and a description of all known species. Four new genera are erected, and five new species are described. A chart showing possible relationships within the group is given. There are figures illustrating the range in colour pattern in the tegmina, and the various forms of the male genitalia in the different species.

Ferrière, C., 1933.—Notes sur les parasites de *Lyperosia exigua* de Meij. *Rev. Suisse Zool.,* xl., 34, 637-644, Dec., 1933.

This paper describes species of parasitic wasps studied in the course of the Council's buffalo-fly investigations. The following are recorded from Java:—Encyrtidae: *Tachinaephagus giraulti* J. and T., *Cerchysius lyperosiae* n. sp.; Pteromalidae: *Pachycrepoideus dubius* Gir., *Spalangia sundaica* Gr.; Eulophidae: *Trichospilus pupivora* Ferrière. From North Australia, two species, *Spalangia orientalis* Gr. and *Phaenopria fimicola* n. sp. (Diapriidae) are recorded.

Freney, M. R., 1933.—Results of Analysis of Australian Wool Samples obtained for Research upon the Blowfly problem. *Bulletin of the Wool Industries Research Association,* vol. iv., no. 3, pp. 11-13, 1933.

Wool samples were analyzed from sheep used for blowfly experiments at Canberra. In order to avoid denaturation of any soluble protein that may have been present, water extraction preceded ether extraction. Four fractions were obtained—suint, wax, dirt, and fibre. Great variation was found in the proportions of the various fractions from different sheep, from different parts of the same sheep, and even from different sections along the length of an individual staple. No correlation of any fraction with susceptibility to strike was deduced from the limited number of samples examined.

Freney, M. R., 1934.—Studies of the Merino Fleece. I. The Chemistry of Suint. *J. Soc. Chem. Ind.,* vol. liii., pt. 18, pp. 131T-134T, May, 1934.

This paper records some results of an investigation of the chemistry of the fleece undertaken as part of the Council's blowfly investigations. Suint is defined as those substances in raw wool which are soluble in warm water, and are separated from other wool elements by simple filtration. The composition of different samples of suint differed considerably. From 10 per cent. to 20 per cent. of the dried weight consisted of fatty acids. The potassium content was high, and the chloride content was lower than in human sweat. No protein was detected, but nitrogenous substances were found which were probably derived from decomposition of protein.

Fuller, M. E., 1933.—The Life History of *Onesia accepta* Malloch (Diptera, Calliphoridae). *Parasitology,* vol. xxv., pt. 3, pp. 342-352. July, 1933.

This blowfly occurred at Canberra under circumstances which rendered it desirable to discover its life history. The author found that it was parasitic in its larval stages on the earthworms, *Microscolex dubius* and *Allolobophora caliginosa trapezoides.* The larval instars and puparium are described and figured, and observations on the biology of the fly are recorded.

Fuller, M. E., 1934.—The Early Stages of *Sciadocera rufomaculata* White (Dipt. Phoridae). *Proc. Linn. Soc. N.S.W.,* vol. lix., pts. 1-2, pp. 9-15, May, 1934.

This aberrant fly breeds in carrion in winter. At a laboratory temperature of 10° C., development from egg to adult is complete in about 80 days. The early stages are described and figured. In a foreword, A. L. Tonnoir points out that the morphology of the larvae confirms the opinion that the fly belongs to the family Phoridae.

Fuller, M. E., 1934.—The Early Stages of *Actina incisuralis* Macq. (Diptera, Stratiomyiidae). *Proc. Linn. Soc. N.S.W.*

Larvae were collected on old, moist carrion during the winter, in moist, decaying grass, and in the moist soil around the roots of growing grass in spring. Adults emerged seven to eight months after the larvae were collected. The external morphology of the larva is described and figured.

Handschin, E., 1933.—Beiträge zur Biologie der Buffelfliege (*Lyperosia exigua* de Meij.) und ihren Parasiten. *Rev. Suisse Zool.,* vol. xl., pt. 8, pp. 187-200, May, 1933.

Handschin, E., 1933.—Studien an *Lyperosia exigua* de Meijere und ihren Parasiten. I. Teil. *Lyperosia exigua* in Java und Nordaustralien. *Rev. Suisse Zool.,* vol. xl., pt. 30, pp. 449-528, July, 1933.

Handschin, E., 1934.—Studien an *Lyperosia exigua* Meijere und ihren Parasiten. II. Teil. Die natürlichen Feinde von *Lyperosia*. *Rev. Suisse Zool.*, vol. xli., pt. 1, pp. 1-71, Feb., 1934.

Handschin, E., 1934.—Studien an *Lyperosia exigua* Meijere und ihren Parasiten. III. Teil. Die Anziehung von Spalangia zu ihren Wirte. *Rev. Suisse Zool.*, vol. xli., pt. 14, pp. 267-297, Mar., 1934.

This series of papers records in detail the results of the Council's buffalo-fly investigations in the Netherlands Indies and North Australia. This work has already been briefly reported in English (this *Journal*, **4**: 234, 1931. Coun. Sci. Ind. Res., Pamphlets 31 and 43).

The preliminary paper is similar to Pamphlet 31, but includes a more complete account of the results of crossing the Australian species of *Spalangia* with the *Lyperosia* strain of the Javan species.

Part 1 includes an historical review and a description of the morphology and biology of the buffalo-fly. Windred's temperature and growth-rate experiments are recorded, and information is given on the distribution of the fly in the more elevated parts of Java. The author's conclusion that the buffalo-fly would not survive in Australia in districts in which the average temperature falls below 20° C. (68° F.) for considerable portions of the year, is based partly on Windred's work, but chiefly on the failure to find buffalo-flies in Java at elevations greater than 1,000 metres.

Part 2 gives a description of the morphology and biology of the parasites, *Spalangia sundaica* Gr., *S. orientalis* Gr., *Alcochara handschini* Scheer., and *A. windredi* Scheer. The author doubts the value of parasites, and considers that predaceous flies might be useful in controlling the buffalo-fly. He mentions species of *Scatophaga*, which attack other flies both in the larval and adult stages, and which occur in the tropics (India).

Part 3 records the experiments on the tropisms of *Spalangia sundaica* and *S. orientalis*. The genetical studies of these species are to be published later.

Hill, G. F., 1933.—Notes on *Porotermes* and *Calotermes* (Isoptera) from the Australian Region, with Descriptions of New Species. *Proc. Royal Soc. Vic.*, vol. xlvi. (n.s.), pt. I., 1933. Read 13th July, 1933. Issued separately 22nd December, 1933.

This paper includes a discussion on the synonymy and distribution of *Porotermes*, descriptions of two new species of *Calotermes* (subgenus *Cryptotermes*), and further descriptions and biological notes on six previously described species of *Calotermes* (subgenera *Calotermes, Neotermes, Glyptotermes,* and *Cryptotermes*). All of the species dealt with are of importance in the destruction of seasoned constructional timber or living trees.

Holdaway, F. G., 1933.—The Synonymy and Distribution of *Chrysomyia rufifacies* (Macq.), an Australian Sheep Blowfly. *Bull. Ent. Res.*, vol. xxiv., pt. 4, pp. 549-560, 5 figs.

The Australian sheep blowfly *Chrysomyia rufifacies* (Macq.), is shown by a study of chaetotaxy and the male genitalia to be distinct from *C. albiceps* with which it has been considered identical. A discussion is given of the composite genus *Chrysomyia* and the genera into which Seguy has recently divided it. The synonymy of *C. rufifacies* is given, and also the distribution of *C. rufifacies*, *C. albiceps*, and *C. putoria*, the three species which Patton has considered synonymous.

Holdaway, F. G., 1933.—Differential Behaviour of *Lucilia sericata* Meig. and *Lucilia caesar* L. in Natural Environments. *J. Animal Ecology*, vol. ii., pt. 2, pp. 263-265, Nov., 1933.

In France, *Lucilia sericata* was active on bright days in open situations, whereas *L. caesar* (including *L. ampullacea* Vill.) was captured chiefly in traps in shady situations, or on dull days in the open. Records of temperature and nebulosity suggest that the range of waves of radiant energy favouring activity of *L. sericata* is higher than that favouring *L. caesar*.

Holdaway, F. G., and Smith, H. F., 1932.—A Relation Between Size of Host Puparia and Sex Ratio of *Alysia manducator* Pantzer. *Aust. J. Expt. Biol. and Med. Sci.*, vol. x., pt. 4, pp. 247-259, 3 figs.

The observations recorded were made (by F. G. H.) when studying the natural enemies of blowflies in France. The sex ratio of parasites (*A. manducator*) emerging from the hosts *Lucilia sericata* Meig., *Calliphora erythrocephala* Meig., *C. vomitaria* Linn., and species of *Sarcophaga* was found to vary from about 100 per cent. of males, from very small puparia, to 100 per cent. females from puparia larger than 46 c.mm. The evidence, which has been examined statistically, suggests that nutrition is an important factor in sex expression in *A. manducator*.

Holdaway, F. G., and Smith, H. F., 1933.—Alteration of Sex Ratio in the "Flour Beetle," *Tribolium confusum* Duval, following Starvation of Newly Hatched Larvae. *Aust. J. Expt. Biol. and Med. Sci.*, vol. xi., pt. 1, pp. 35-43, 1 fig.

Groups of newly hatched larvae of *Tribolium confusum* were submitted to starvation respectively for one day, two days, and three days before being placed in flour, control larvae being placed immediately in flour. Uniform conditions of humidity, temperature, and light were maintained. Starvation for two or three days resulted in an excess of females, which could not be explained as due to differential mortality. The results are shown to be statistically significant, and contrary to most observations recorded in previous publications on the possible effect of nutrition on sex in animals.

Krijgsman, B. J., en Windred, G. L., 1930.—De gastheerkeuze van bloedzuigende Arthropoden. Deel II., *Lyperosia exigua*. *Ned. Ind. Blad. v. Diergeneesk*, vol. xlii., pt. 2, pp. 110-120.

KRIJGSMAN, B. J. und WINDRED, G. L., 1930.—Reizphysiologische Untersuchungen an blutsaugenden Arthropoden in Zusammenhang mit ihrer Nahrungswahl. II. Teil: *Lyperosia exigua*. *Zeit. f. vergl. Physiol.*, vol. xiii., pt. I., pp. 61-73.

KRIJGSMAN, B. J., en WINDRED, G. L., 1931.—Physiologisch-oecologische onderzoekingen over *Lyperosia exigua*. Deel I: De relatie tusschen de volwassen *Lyperosia* en zoogdierfaeces. *Ned. Ind. Blad.* v. *Diergeneesk.*, vol. xliii., pt. 2, pp. 113-131.

The second paper is a German translation of the first, with additions. The first and second papers have been summarized, and the third translated into English in the Council's Pamphlet No. 43, pp. 7-19.

MACKERRAS, I. M., 1932.—The Australian Species of *Graphomyia* (Diptera, Muscidae). *Proc. Linn. Soc. N.S.W.*, vol. lvii., pts. 5-6, pp. 361-363, Dec., 1932.

Graphomyia maculata rufitibia Stein and *Gr. campbelli* n. sp. are recorded, the former from North Australia, Queensland, and New South Wales, the latter from North Australia.

MACKERRAS, I. M., 1933.—The Taxonomy of *Lyperosia exigua* de Meijere (Diptera, Muscidae). *Ann. Mag. Nat. Hist.*, ser. 10, vol. xi., No. 61, 58-64, Jan., 1933.

The generic name *Lyperosia* is shown to be correctly applied, with *irritans* Lin. as the genotype. The buffalo-fly, *L. exigua* de Meij., is shown to be congeneric with *L. irritans* Lin., and characters for distinguishing between the two species are given. The species of *Lyperosia* from Australia is identical with that from Java.

MACKERRAS, I. M., 1933.—The Metamorphosis of *Filaria bancrofti* Cobbold. *British Med. J.*, 1st July, 1933, p. 36.

The history of the discovery of the life-history of *Filaria bancrofti* in the mosquito is reviewed, with special reference to the work of T. L. Bancroft.

MACKERRAS, I. M., 1934.—The Venom of *Atrax robustus* Cambridge. *Med. J. Aust.*, 16th June, 1934, p. 794.

Notes are given on the habits of the venomous funnel-web spider, on the method of collecting venom, and on experimental bites. None of the three guinea-pigs bitten showed any symptoms that were attributable to the bites. These results are similar to those reported by Kellaway.

MACKERRAS, M. J., 1933.—Note on the Occurrence of a White-eyed Mutant Race of *Lucilia cuprina* Wied. *Aust. J. Expt. Biol. and Med. Sci.*, vol. xi., pt. 1, pp. 45-47, Mar., 1933.

This mutant appeared in a culture of the primary green sheep blowfly, *Lucilia cuprina*, which is maintained at Canberra. It behaved as a unit recessive character, and was not sex-linked.

Mackerras, M. J., 1933.—Observations on the Life-Histories, Nutritional Requirements, and Fecundity of Blowflies. *Bull. Ent. Res.*, vol. xxiv., pt. 3, pp. 353-362, Sept., 1933.

Five common species of sheep blowflies, *Lucilia cuprina, L. sericata, Calliphora stygia, C. augur,* and *Chrysomyia rufifacies,* have been bred for many generations in captivity. Inbreeding does not affect their vigour, and they breed just as well in artificial light as in sunlight. The longest life (94 days) and greatest oviposition (3,171) occurred in a hybrid *L. cuprina* x *L. sericata.* Protein food is necessary for maturation of eggs, but not of spermatozoa. Copulation is an essential stimulus for oviposition, and eggs are laid in any situation where tactile stimuli are appropriate, irrespective of whether there is food for the larvae or not. The number of eggs produced by a fly depends on its size, and consequently on the food it was able to secure as a larva.

Mackerras, M. J., and Freney, M. R., 1933.—Observations on the Nutrition of Maggots of Australian Blowflies, *J. Expt. Biol.*, vol. x., pt. 3, pp. 237-246, July, 1933.

Lucilia cuprina, L. sericata, and *Chrysomyia rufifacies* produce peptic and tryptic enzymes, and can liquefy and digest solid food without the aid of bacteria. Predatory activity, though a normal habit of *Ch. rufifacies,* is not necessary for full development of this species. Moisture, warmth, shelter, aeration, and an alkaline reaction favour development of the larvae. Partial growth of larvae takes place in sheep-dung, faeces-soiled wool, and the products of keratin hydrolysis. These substances are sufficient for initial development of the larvae on the live sheep. When they invade the skin, there is a copious serous exudation, which was shown to be an adequate food for complete development. The relation of bacterial activity to strike in sheep is discussed.

Nicholson, A. J., 1933.—The Balance of Animal Populations. *J. Animal Ecology,* vol. ii., no. 1, pp. 132-178.

The mechanism of competition and its effects upon the population densities of animals are discussed. A characteristic feature of competition is shown to be a strong tendency to bring the population density of each species to a value at which exact balance with the environment exists. This value is determined partly by the properties of the species, and partly by those of its environment. Consequently, populations of animals vary in density in close relation with variations of their environments, such as those of climate. It is further shown that the interaction of natural enemies and their prey is fundamentally a special kind of competition, but such interaction causes oscillations in the densities of animals, even in a constant environment. The combined influence of these oscillations and of other factors is to cause many interesting phenomena, such as the splitting of a population into a large number of widely separated groups of individuals, or the occurrence of fluctuations in density which have no apparent relation with any changes in the environment.

The influence of various types of interaction between animals, and of a number of other factors, on the population densities of animals is examined theoretically, and is illustrated by numerical examples and graphs. Finally, the results of this investigation of the mechanism of competition are shown to have an important bearing upon the theory of natural selection.

Nicholson, A. J., 1934.—The Influence of Temperature on the Activity of Sheep Blowflies. *Bull. Ent. Res.*, vol. xxv., pt. 1, pp. 85-99, Mar., 1934.

Adults of *Lucilia cuprina* Wied., *L., sericata* Mg., *Calliphora stygia* Fabr., and *Chrysomyia rufifacies* Wied., were submitted to a series of constant temperatures, and also to steadily rising temperatures. The activity of the flies during the period of observation was recorded quantitatively, and "activity curves" were constructed for each species. When the flies were exposed to a series of constant temperatures, the greatest activity of all species occurred near the centre of the temperature range, whereas with rising temperature the maximum was just before the upper thermal death point. The activity curves of the four species differed, and were found to be in conformity with the geographical and seasonal distribution of the species. Studies of flight activity suggest that *L. cuprina* would be more active than the other species on warm, overcast days. The relation of these findings to the results obtained by other workers with different insects is discussed.

Scheerpeltz, O., 1934.—Zwei neue Arten der Gattung *Aleochara* Gravh. (Coleopt. Staphylinidae), die aus den Puppen von *Lyperosia* (Dipt.) als Parasiten gezogen wurden. *Rev. Suisse Zool.*, xli., 6, 131-147, Feb., 1934.

This paper describes species of beetles studied in the course of the Council's buffalo-fly investigations. *Aleochara* (*Isochara*) *handschini* n. sp., from Java and Flores, and *Al.* (*I.*) *windredi* n. sp., from North Australia, are described, both species being parasitic on the puparia of *Lyperosia exigua* de Meij. A key is given to the Palaearctic, Oriental, and Australian species of the subgenus *Isochara*.

Tillyard, R. J., 1932.—The Evolution of the Class Insecta. *Amer. J. Sci.*, vol. xxiii., pp. 529-539.

This communication is a reply to the criticisms made in a symposium (*Amer. J. Sci.*, vol. xxi., pp. 531-539, 1931) on Dr. Tillyard's original paper of the same title, which has already been summarized in this *Journal* (**5**: 184, 1932).

Tillyard, R. J., 1932.—Origin of Insects from Crustacea. *Nature*, 4th June, 1932.

The author concludes that evidence from the study of the early stages of *Allomachilis* sp. (Thysanura) disposes of the main remaining argument in support of the theory of the crustacean origin of insects.

Tillyard, R. J., 1933.—The Mayflies of the Mount Kosciusko Region. *Proc. Linn. Soc., N.S.W.,* vol. lviii., pts. 1-2, pp. 1-32, 1 pl., 45 figs.

Keys are given to the Australian and New Zealand genera, and species of the family Siphlonuridae. This family is reviewed, and two new genera and five new species are described. Information is given on the life histories and distribution of the mayflies concerned.

Tillyard, R. J., 1933.—The Trout-food Insects of Tasmania. Part I. A Study of the Genotype of the Mayfly Genus *Atalophlebia* and its Life History. *Royal Soc. Tas., Papers and Proc.,* pp. 1-16, 1933.

A full description of the mayfly *Atalophlebia australis* Walker is given, together with information on its importance as trout food.

Tonnoir, A. L., 1929.—Australian Mycetophilidae. Synopsis of the Genera. *Proc. Linn. Soc. N.S.W.,* vol. liv., pp. 584-614, 2 pl., 7 figs.

Our previous knowledge of the family is reviewed; a discussion of the affinities of this part of our dipterous fauna is made; and a list of the 47 recognized Australian genera is given, 10 of them being new to science. A key to the genera of the world is given, with a discussion of some morphological features, especially of the venation, necessary for the use of the key. Each genus is there discussed, and 12 new species are described in order to validate the new genera. On the two plates, micro-photographs of the wings of most genera are given.

Tonnoir, A. L., 1930.—Notes on the Genus *Apistomyia* (Dipt. Blepharoceridae) and a Description of a New Species. *Proc. Linn. Soc. N.S.W.,* vol. lv., pp. 136-144, 14 figs.

The world distribution of this genus is discussed, and a key is given to the five known species. A new species is described from Java as well as its larva and pupa, and also the larva of some unknown species.

Tonnoir, A. L., 1930.—Notes on Indian Blepharocerid (Dipt.) Larvae and Pupae, with Remarks on the Morphology of Blepharocerid Larvae and Pupae in General. *Records of the Indian Museum,* vol. xxxii., pp. 161-214, 58 figs.

In this paper, an extensive collection of larvae and pupae made by Dr. G. L. Hora is studied, 15 distinct types, most of which are new to science, being described and illustrated. Two new genera are erected, but only two new species are named, as few adult insects were available in the material studied. A general discussion of the early stages of the family is made, and the process of pupation is described in detail.

Tonnoir, A. L., 1931.—Notes on Some Types of Indian Blepharoceridae (Dipt.). *Records of the Indian Museum,* vol. xxxii., 1931, pp. 283-290, 8 figs.

A re-description of the types of several species of Blepharocerid are made from the actual specimens submitted by the authorities of the Indian Museum.

Tonnoir, A. L., 1932.—Notes on Indian Blepharoceridae. *Records of the Indian Museum,* vol. xxxiv., pp. 269-275, 2 figs.

Several genera and species of Blepharoceridae are here discussed, and one new species of *Horaia* described.

Tonnoir, A. L., 1933.—Description of Remarkable Psychodidae and Their Early Stages, with a Theory of the Evolution of the Ventral Suckers of Dipterous Larvae. *Records of the Indian Museum,* vol. xxxv., pp. 53-75, 7 figs., 1 pl.

The descriptions of two species in the larval, pupal, and adult stages of the new genus *Horaiella* are here given, and the affinities of this new form are discussed in detail. A remarkable feature of the larva figured is a single and very large ventral sucker which, according to the author, explains the evolution of the series of suckers in larvae of other families, such as the Blepharoceridae. A new subgenus *Neotelmatoscopus* is also described in all its stages, the larva being also remarkable for the presence of ventral suckers.

Tonnoir, A. L., 1934.—Notes synonymiques sur quelques Psychodidae (Dipt.) *Bull. et Ann. de la Société entomologique de Belgique,* vol. lxxiv., pp. 69-82.

The synonymy, generic status, and validity of about 20 species from all parts of the world are discussed in this paper; 4 of them are species found in Australia.

Womersley, H., 1932.—A Preliminary Account of the Protura of Australia. *Proc. Linn. Soc. N.S.W.,* vol. lvii., pp. 69-76.

Six species of Protura collected in Australia, and all new to science, are described and named. A key to the Australian families and genera is given. Two new sub-families and two new genera are erected to include the Australian species. These are the first species described from Australia.

The Pore Size (Vessel Diameter) of some Australian Timbers and their Susceptibility to Attack by the Powder Post Borer (*Lyctus brunneus* Stephens).

By J. E. Cummins, M.Sc. and H. B. Wilson, B.Sc.†*

1. Introduction.

The destruction of the sapwood of commercial timbers by *Lyctus* (powder post) beetles is a matter of economic importance throughout the world, and many investigators have devoted considerable time to a study of the problem. To date, however, satisfactory control methods have not been devised, although a recent publication by S. E. Wilson (1) demonstrating the relationship between *Lyctus* attack and the starch content of the sapwoood has opened up a new and promising field of work.

In Australia, the sapwood of a large number of the commercial species of timber is susceptible to attack by *Lyctus,* and, as a result, it has become the practice in specifications to exclude the sapwood of these timbers. This is a definite economic waste of otherwise good timber. In some species of Australian timbers, sapwood development is extensive, and may extend to a radial depth of 6 inches in a log normally measuring about 18 inches to 2 feet in diameter. Some of these timbers possess properties which make them highly desirable for furniture and veneer purposes, but the high susceptibility to *Lyctus* renders their commercial exploitation for these purposes unsatisfactory at present. Also, in regrowth material, utilization of the sapwood is essential to economic working of the forest. Many other examples may be given, but the value of developing effective methods for the control of *Lyctus* is obvious.

The Division of Forest Products has been studying this problem for some time past, and this paper records the results of investigations on one particular aspect only. Primarily, it was conducted to determine the applicability, to Australian timbers, of the results of work on the relationship between vessel size and attack by *Lyctus* carried out by S. H. Clarke (2) in England. General information available at the time of the publication appeared to indicate that some modification of the main conclusions would have to be made.

2. Review of Literature.

In 1916, T. E. Snyder (3) showed that *Lyctus planicollis* deposits its eggs in the pores or vessels of hardwoods. In 1922, A. M. Altson (4) established the same method of oviposition for *L. brunneus.* In 1928, Munro (5) observed that only those timbers with pores of moderate size are suitable for infestation, and pointed out that close-grained, narrow-pored woods, such as mahogany (*Swictenia* sp.), birch, beech, and maple are not attacked.

* Senior Preservation Officer, Division of Forest Products.
† An officer attached to the Section of Timber Preservation, Division of Forest Products.

Clarke (2) published in 1928 the results of work on the relationship between the diameter of the eggs of *L. brunneus* and of the vessels of a number of susceptible and non-susceptible timbers. He gave distribution curves for the vessel diameter of each genus investigated. The radial and tangential diameters of each vessel were measured, and the average of the two figures taken. The vessel diameter ranges were compared with the minimum and mean of the maximum diameters of 20 eggs of *L. brunneus*. The maximum diameter of the smallest egg measured by Clarke was 137μ, and in his discussion he regards this as the minimum size possible, and concludes that, where the largest vessels of a given wood are less than 137μ in diameter, it would be highly improbable that the wood would be attacked. The data presented indicated that this theory held for six species of timber whose maximum pore size was less than 137μ, a survey of the records available indicating that none of them had ever been recorded as infested by *Lyctus*. Clarke also considered that the minimum measurement of the maximum diameter of a *Lyctus* egg is the critical figure, but it is not as important as the mean figure, and the greater the percentage of vessels whose mean diameter exceeds the mean egg diameter the greater the probability of attack.

It appears that Clarke's conclusions require certain modifications. Only 20 measurements of *Lyctus* eggs were given by him, the range of maximum diameters for 19 of these being from 137 to 159μ, the remaining egg measuring 183μ. The standard deviation for the 19 eggs is 7, so that 99.73 per cent. of the measurements made on a large number of eggs would be expected to fall within the range of 126 to 168μ. It appears, therefore, that if more measurements had been made, some eggs would probably have been found to be less than 137μ, and there is a possibility of 7 eggs in 1,000 measuring less than 130μ. It appears safer, therefore, on the data presented, to place a limiting pore size, assuming other factors are favorable, at a maximum of about 126μ. The extent of damage to the wood and the possibility of attack do not appear to be limited by the percentage of total pores above the mean, or even the minimum diameter of the *Lyctus* eggs, provided some pores are sufficiently large for oviposition. Even though only a small percentage of the pores are above the minimum size required for oviposition, there is still the probability of severe attack, and Australian experience indicates that this definitely occurs. In the early stages, the larval damage may appear slight, apparently due to oviposition of eggs at relatively large intervals, but there may be sufficient larvae present to cause serious damage, even up to almost complete destruction of the sapwood eventually.

In 1923, Roughley and Welch (6) published a list of Australian and exotic timbers which they had observed to be attacked by *Lyctus*. No pore or egg measurements were made, but an examination of this list shows that some of the Australian species have been recorded by the Wood Structure Section of the Division of Forest Products as having maximum pore sizes below that given by Clarke, and yet such timbers are recorded as very susceptible to bad infestation.

In 1933, K. A. Chowdhury (7) measured the maximum diameters of 10 eggs of *Lyctus africanus*, and found these to be almost constant at about 130μ. Measurements were made of the pore sizes of 52 species of Indian timbers, all except three being recorded as attacked by *Lyctus*. Chowdhury measured both radial and tangential pore diameters, and concluded that oviposition can only occur in those vessels whose

tangential and radial diameters are each larger than the diameter of the eggs. He presents graphical results showing the possibility of *Lyctus* attack as dependent upon the percentage of vessels with a minimum diameter greater than 130μ. His figure for the limiting *Lyctus* egg diameter is open to the objection that too few measurements were made, and to the fact that all these were recorded from timber which was placed in containers together with a limited number of beetles. Again, there is no evidence for assuming that the probability of attack depends upon the percentage of pores above a certain fixed minimum diameter, when in all cases there are some pores of sufficient size available for oviposition.

E. A. Parkin, in 1933, (8), and 1934, (9)*, reported that since the publication of Clarke's work, samples of *Acer pseudoplatanus* and *Schizomeria ovata* (Australian crab apple) infested by *Lyctus* had been received. On the basis of pore size, both of these timbers would have been considered as immune to attack. Parkin gives a detailed account of the probable method of egg laying. It was found that the egg is considerably elongated in its passage down the ovipositor of the beetle, and, as it issues from the ovipositor, it generally shortens in length and expands in diameter to give a so-called "normal" diameter. If, however, the pore is smaller than the "normal" diameter, this expansion is not possible, and an elongated egg will result. The original theory of Clarke is, therefore, modified, and the susceptibility to *Lyctus* attack is based on the relationship between the vessel diameter of the timber and the ovipositor diameter of the beetle. Measurements of the ovipositor of 34 beetles of *L. brunneus* gave an average diameter of 78μ with a minimum of 56μ, and Parkin states that it is apparently possible for eggs to be laid in woods which have an average vessel diameter sufficiently large to allow of introduction of the ovipositor. He also measured 20 "normal" eggs of *L. brunneus*, and recorded a range of from 125μ to 180μ, with an average of 142μ.

3. Measurement of Eggs of *Lyctus brunneus*.

Measurements of eggs were made during two seasons of beetle emergence, a total of 75 eggs being measured. All these eggs were laid in timber which was submitted to infestation by *Lyctus* beetles in petri dish containers. Several different species of wood, all of large pore size, were used as the host, and the beetle stock used varied considerably in size of individuals and was obtained from about 50 different species of timber. All the first year's stock was subsequently identified by Dr. R. C. Fisher, Forest Products Research Laboratory, Princes Risborough, England, as *Lyctus brunneus* Stephens, and later material has also been carefully examined to ensure correct identity. In the second season's measurements, eggs were measured in *E. regnans* only.

The small pieces of infested timber were carefully pared down on a microtome. The freshly cut faces were examined under a binocular microscope, and any eggs found were measured *in situ*. In some cases, the eggs were removed from the wood and re-measured, but no appreciable difference was found in the result. Measurements were made of the maximum diameters, length of "body" and length of "tail," if possible, three separate readings being taken and averaged.

* Parkin's detailed paper was received while this manuscript was in course of publication.

The maximum diameter of the egg was found to be at the slightly distended region behind the tail, and all eggs measured were fully exposed near this point. "Body" and "tail" measurements could not be made on all eggs owing to frequent partial concealment by portions of the vessel walls. They are apparently not significant in determining the size of vessel necessary for egg oviposition, but are included for completeness. No measurements were made on any eggs which showed signs of distortion due to drying or external pressure.

The detailed measurements for the 75 eggs are given in Table 1, and their frequency distribution shown in Fig. 1. The maximum, minimum, mean, and standard deviation of the recorded maximum *Lyctus* egg diameters are:—Minimum, 110μ; maximum, 163μ; mean, 136μ; and standard deviation, 10.8μ.

TABLE 1.

Measurement of *Lyctus brunneus* Eggs Laid in Large-pored Woods.

Egg No.	Maximum Diameter (Average of Three Observations.)	Length of Body of Egg (Average of Three Observations.)	Length of Tail (One Observation only.)	Egg No.	Maximum Diameter (Average of Three Observations.)	Length of Body of Egg (Average of Three Observations.)	Length of Tail (One Observation only.)
	(Microns.)	(Microns.)	(Microns.)		(Microns.)	(Microns.)	(Microns.)
1	135	..	..	39	141	..	..
2	110	..	..	40	141	869	..
3	133	985	..	41	154	957	..
4	133	897	..	42	134	1,154	..
5	132	921	..	43	136	991	..
6	138	880	..	44	138	1,093	..
7	136	..	..	45	128	830	..
8	134	1,146	364	46	135	939	..
9	119	983	..	47	127	..	..
10	141	881	..	48	133	..	..
11	136	894	538	49	121	1,196	246
12	138	1,002	..	50	121	..	..
13	138	1,115	..	51	127	..	..
14	142	961	..	52	146	..	..
15	142	993	..	53	144	1,049	165
16	139	954	..	54	123	931	402
17	128	1,011	227	55	127	..	..
18	139	988	274	56	129	975	..
19	140	906	250	57	136	960	..
20	125	..	..	58	139	..	..
21	163	961	297	59	157	1,064	..
22	142	962	278	60	140	..	..
23	136	..	..	61	140	990	..
24	158	832	97	62	133	1,069	..
25	139	..	..	63	134	1,029	..
26	124	..	..	64	127	1,038	..
27	160	862	278	65	125	993	..
28	118	1,046	116	66	138	1,097	..
29	137	962	..	67	152	1,032	..
30	137	947	..	68	137	..	..
31	144	840	271	69	145	948	..
32	129	650	..	70	112	923	..
33	142	867	..	71	137	899	..
34	138	1,031	..	72	130	..	..
35	149	738	278	73	124	1,001	..
36	156	893	..	74	119	891	..
37	143	1,010	427	75	122	970	..
38	136	..	..				

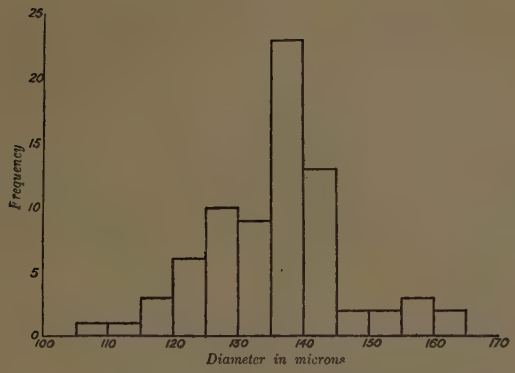

FIG. 1.—Frequency of maximum diameters of 75 *Lyctus brunneus* eggs.

4. Measurements of Vessel Diameters.

Microscopic sections were prepared from 94 different species of timber, the material being taken in all cases from stock infested with *Lyctus*. In 47 of these specimens, sections were prepared by the Section of Wood Structure from the truewood (heartwood) adjoining the infested sapwood, and measurements made of the radial diameter of the ten largest pores in a cross section. It is reasonable to suppose, and it is assumed, that the measurements of vessels in sapwood and adjoining truewood are similar. Even allowing a small difference, all the woods so measured contained some pores greater than 180μ. Most of the species so measured have their radial diameter greater than the tangential, but their pore sizes are so large that, even allowing a ratio of radial to tangential diameter of $1\frac{1}{2}$ to 1, the minimum size so recorded would be above 120μ.

In the remaining 48 specimens, sections were prepared from infested sapwood. The minimum diameter of each of the largest ten pores in any one section was recorded, the minimum diameter being considered as the limiting one for normal egg deposition (see also Chowdhury). The ranges of the vessel measurements made with each species are recorded in Table 2. It will be noted that approximate figures only are given in three species, but in each case the vessel diameters are large.

Table 2.

Vessel Diameters of Timbers Infested with *Lyctus*.

Species.	Diameter. (Microns.)
Acacia dealbata (1)	170–225
„ *implexa* (3)	200
„ *melanoxylon* (1) ..	170–225
Aleurites moluccana (2) ..	195–265
Angophora bakeri (1) ..	215–260
„ *intermedia* (1) ..	155–210
„ *lanceolata* (1) ..	175–250
„ *subvelutina* (3) ..	195
Baloghia lucida (2)	86–116
Cedrela australis (1)	235–340
Embothrium wickhami (1) ..	175–225
Ficus macrophylla (2) ..	135–265
Flindersia bennettiana (2) ..	102–139
Grevillea robusta (1)	205–270
Litsea reticulata (1)	175–230
Nothofagus moorei (2) ..	69–86
Orites excelsa (2)	105–129
Panax elegans (2)	79–107
„ *murrayi* (2)	120–160
Schizomeria ovata (2) ..	80–111
Sterculia acerfolia (2) ..	180–215
Syncarpia laurifolia (1) ..	135–215
Tarrietia peralata (1) ..	200–235
„ *actinophylla* (3) ..	190
Tristania suaveolens (1) ..	125–180
Eucalyptus accedens (2) ..	110–150
„ *aggregata* (2) ..	120–145
„ *amplifolia* (2) ..	125–155
„ *angophoroides* (2) ..	97–123
„ *australiana* (1) ..	200–310
„ *baileyana* (2) ..	135–180
„ *bancrofti* (2) ..	125–170
„ *baueriana* (2) ..	102–139
„ *bicolor* (2) ..	84–105
„ *bicostata* (2) ..	135–180
„ *blakeleyi* (2) ..	103–128
„ *bosistoana* (1) ..	200–230
„ *botryoides* (2) ..	175–210
„ *bridgesiana* (1) ..	200–250
„ *calophylla* (1) ..	245–340
„ *canaliculata* (2) ..	160–205
„ *cinerea* (2) ..	120–170
„ *coriaceae* (1) ..	155–225
„ *corymbosa* (2) ..	180–235
„ *crebra* (2) ..	125–150
„ *dalrympleana* (1) ..	210–310
„ *deanei* (2) ..	175–210

Species.	Diameter. (Microns.)
Eucalyptus de beuzevillei (2) ..	120–145
„ *diversicolor* (1) ..	315–380
„ *dives* (1)	165–265
„ *eleaeophora* (2) ..	200–260
„ *eximia* (2) ..	165–235
„ *fastigata* (1) ..	210–315
„ *fraxinoides* (2) ..	145–160
„ *gigantea* (1) ..	245–320
„ *globulus* (1) ..	180–315
„ *gomphocephala* (1) ..	180–270
„ *goniocalyx* (1) ..	200–335
„ *kirtoniana* (2) ..	165–200
„ *leucoxylon* (1) ..	160–260
„ *longifolia* (2) ..	102–138
„ *macarthuri* (1) ..	150–300
„ *macrorrhyncha* (1) ..	180–230
„ *maculata* (1) ..	165–280
„ *maideni* (1) ..	200–330
„ *melliodora* (1) ..	145–205
„ *microcarpa* (2) ..	120–138
„ *microcorys* (1) ..	200–290
„ *nitens* (2) ..	140–170
„ *obliqua* (1) ..	205–240
„ *ovata* (2)	120–155
„ *paniculata* (2) ..	135–150
„ *parramatensis* (2) ..	150–170
„ *patens* (1) ..	205–240
„ *perrineana* (2) ..	110–150
„ *pilularis* (1) ..	210–240
„ *piperita* (1) ..	185–295
„ *polyanthemos* (2) ..	125–160
„ *regnans* (1) ..	260–385
„ *resinifera* (2) ..	190–255
„ *robertsoni* (2) ..	165–210
„ *robusta* (2) ..	145–180
„ *rostrata* (2) ..	120–145
„ *rubida* (2) ..	135–195
„ *seeana* (2) ..	130–250
„ *sideroxylon* (2) ..	135–185
„ *smithii* (2) ..	120–150
„ *stellulata* (2) ..	110–150
„ *stuartiana* (1) ..	200–250
„ *tereticornis* (2) ..	155–255
„ *tesselaris* (2) ..	180–235
„ *trachyphloia* (2) ..	150–205
„ *umbra* (1) ..	175–235
„ *viminalis* (1) ..	200–335

(1) Range of maximum radial diameters of ten largest pores measured in the truewood.
(2) Range of minimum diameters of ten largest pores measured in sapwood.
(3) Approximate minimum diameter of largest pores.

5. The Relationship between Egg and Vessel Measurements and Infestation.

An examination of Table 2 reveals that, with the exception of eight species, the vessel diameters measured overlap the mean egg diameter recorded. Of the eight species, three of them, namely *Oriles excelsa, E. angophoroides,* and *E. blakeleyi,* contain some vessels above 110μ, thus allowing of oviposition of "normal" small eggs. In the remaining five species, the initial measurements indicated that the maximum pore size of some was extremely small. A further series of blocks was cut from the same samples of infested sapwood of these species, and further measurements made. These are recorded in Table 3 below.

TABLE 3.

Species.	Maximum of Minimum Diameters of Largest Pores in Cross Sections Examined.	
	First Series of Measurements.	Second Series of Measurements (Three Blocks from Each Sample.)
	(Microns.)	(Microns.)
Baloghia lucida	116	115
Nothofagus moorei	86	104
Panax elegans	107	112
Schizomeria ovata	111	119
E. bicolor	105	119

It was found, except with *B. lucida,* that it was possible to find a very small number of pores larger than previously recorded. With the exception of *N. moorei,* some pores were found above the minimum *Lyctus* egg measured. The scarcity of these large pores, however, makes it extremely unlikely that they are responsible for the observed infestation by having "normal" small eggs oviposited within them. More especially is this so in the case of *N. moorei,* although this species has so far only been recorded as lightly infested. It appears obvious, therefore, that eggs of smaller dimensions than those measured during this investigation can be oviposited. It does not appear possible, however, from statistical analyses of the measurements obtained, for any large number of "normal" eggs to be present in these species, and Parkin's theory appears in this case to offer a satisfactory explanation.

An experiment was made by placing small sapwood blocks of small-pored timbers into petri dishes and adding to the dishes six male and six female beetles. Some time later, the specimens were removed and carefully pared down on a microtome, and the freshly cut surfaces examined for eggs or evidence of larval borings. The results of the examination and the range of the minimum diameter of the largest pores are given in Table 4.

This again confirms the examination of naturally infested material. Indications appear to be that, in Australia, the sapwood of hardwoods containing pores with a minimum diameter greater than about 90μ will be susceptible to attack, other factors being satisfactory.

TABLE 4.

Species.	Range of Minimum Diameter of Largest Pores.	Results of Examination.
	(Microns.)	
E. salubris	40–46	Eggs and borings absent
Atherosperma moschata ..	49–59	Eggs and borings absent
Eucryphia billardieri	53–63	Eggs and borings absent. Forty eggs found between a specimen and bottom of container
Eriostemon squameum ..	59–74	Eggs and borings absent
Olearia argophylla	72–86	One boring present
Nothofagus cunninghami ..	68–88	Borings present
Daphnandra micrantha ..	68–91	Eggs and borings absent
Harpullia pendula	72–96	Borings present
Schizomeria ovata	90–119	Borings present

Parkin (9) considers that it is apparently possible for eggs to be laid in timbers containing vessels sufficiently large for introduction of the ovipositor, i.e., vessels with a minimum average diameter of about 56μ. From the data available, it does not appear possible for infestation to occur under Australian conditions in woods containing pores with a minimum diameter less than about 90μ. It appears, therefore, that there is some other factor which is accounting for the differences observed in the minimum ovipositor measurements of Parkin and the oviposition and development of eggs in Australian timbers. No measurements have been made in Australia of ovipositor diameters, and no definite explanation can be at present advanced to account for this difference.

Unfortunately, all the main commercial species of Australian hardwoods have pore sizes greater than 90μ, and the investigation of methods of treatment of susceptible sapwood is of the utmost importance.

6. Conclusions.

1. Measurements of "normal" *Lyctus brunneus* eggs show a variation in maximum diameter of from 110μ to 163μ, the mean being 136μ.

2. The original theory of Clarke requires considerable modification when applied under Australian conditions.

3. Natural infestation by *Lyctus* has been recorded on 94 species of Australian timbers, the largest minimum pore sizes ranging from 104μ to over 300μ.

4. Severe attack occurs in species of timber, the largest pores of which have a minimum diameter similar to, or less than, that of the smallest egg recorded, namely 110μ. The percentage of such pores is sometimes only small.

5. The maximum diameter of the "normal" *Lyctus* egg is not the only factor governing the pore size necessary for oviposition, as oviposition definitely and commonly occurs in vessels less than 110μ in diameter.

6. It appears that the limiting minimum pore diameter for oviposition in Australia is about 90μ, and that the sapwood of timbers with pore sizes above 90μ cannot be considered as immune to attack, provided other factors are satisfactory.

7. Parkin's theory gives a satisfactory explanation of those cases of oviposition in pores of less diameter than that of a "normal" *Lyctus* egg. The limit of pore size in which infestation may occur in Australia appears to be somewhat higher than the actual dimension of the ovipositor recorded by Parkin.

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Thrips Investigation.

4. Some Observations on the Fluctuations in the Numbers of *Thrips imaginis* Bagnall, in the vicinity of Melbourne during the period 1932 to 1934.

By H. G. Andrewartha, M.Agr.Sc. and H. Vevers Steele, B.Agr.Sc., M.Sc.†*

(*From the School of Agriculture, University of Melbourne.*)

The work described in the following article forms part of the programme of investigations on thrips which are being carried out as a co-operative enterprise between the Thrips Investigation League, the Council for Scientific and Industrial Research, the Waite Agricultural Research Institute of the University of Adelaide, the University of Melbourne, and other bodies. Through the helpful co-operation of the University of Melbourne, laboratory accommodation and other facilities have been generously made available at the University's School of Agriculture, in connexion with the investigations in Victoria (see this *Journal*, 6: 216, 1933). The article discusses work centred at that School.—Ed.

Summary.

Fluctuations in the numbers of *Thrips imaginis* in Victoria which occurred during the period, September, 1932, to July, 1934, are recorded. Attention is drawn to certain meteorological factors which appear to be associated with these fluctuations.

Particular stress is placed upon the important role played by soil moisture in the preceding autumn in relation to the numbers which develop the following spring.

The theory is advanced that in Victoria the main "feed" for the spring generation comes from overwintering adults.

It is shown that this "feed" was relatively large in the spring of 1932, and very small in the spring of 1933.

1. Introduction.

Since September 1932 (with the exception of May, 1933), records have been made of the fluctuations in the numbers of *Thrips imaginis* occurring in flowers in the grounds of the University of Melbourne. The purpose of this paper is to place on record the data which have so far been accumulated, and to call attention to certain conditions in the physical environment of the insects which play an important part in regulating these fluctuations. The records are being continued‡.

2. Methods.

Up to November, 1933, difficulty was experienced in obtaining a suitable plant for continuous sampling. The samples were taken mostly from Cecil Brunner roses; at different times, mainly during the winter, white daisies, white clover, sweet peas, and Iceland poppies were used. Before changing from one species of plant to another, samples for thrips counts were taken concurrently from both species of plants so as to ascertain the relative levels of the numbers of thrips in each. In this way, it was possible to adjust the figures so as to give a reliable and continuous record of the numbers of thrips present during the period under review. Since November, 1933, samples have been taken consistently from Cecil Brunner roses§, twenty flowers (at about the same

* An official of the Council accommodated at the School of Agriculture, University of Melbourne.

† A Research Scholar of the University of Melbourne.

‡ The latitude of Melbourne is about 3° south of that of Adelaide, the winter being wetter and colder. The observations on *T. imaginis* recorded in this article may be compared with those recorded in the neighbourhood of Adelaide (Evans 1933A, 1934).

§ In this connexion, our thanks are due to Mr. R. W. Hodgins of Watsonia, who very kindly donated 100 bushes of Cecil Brunner roses, which were planted in the University grounds.

stage of development, i.e., just fully open) were picked each day; the thrips were extracted from them in a "turpentine jar" very similar to that described by Evans (1933).

The curves in Figs. 1 to 4 have been partially smoothed; they show the average of the daily records for each ten-day period.

3. Discussion.

In Fig. 1, the numbers of adult thrips in twenty roses have been plotted for the full period September, 1932, to July, 1934. It presents a general picture of the seasonal fluctuations in the numbers of *Thrips imaginis* around Melbourne. Normally, the insect is abundant in the late spring (about November) and during early summer. There is a marked decrease in numbers later in the summer and in early autumn,

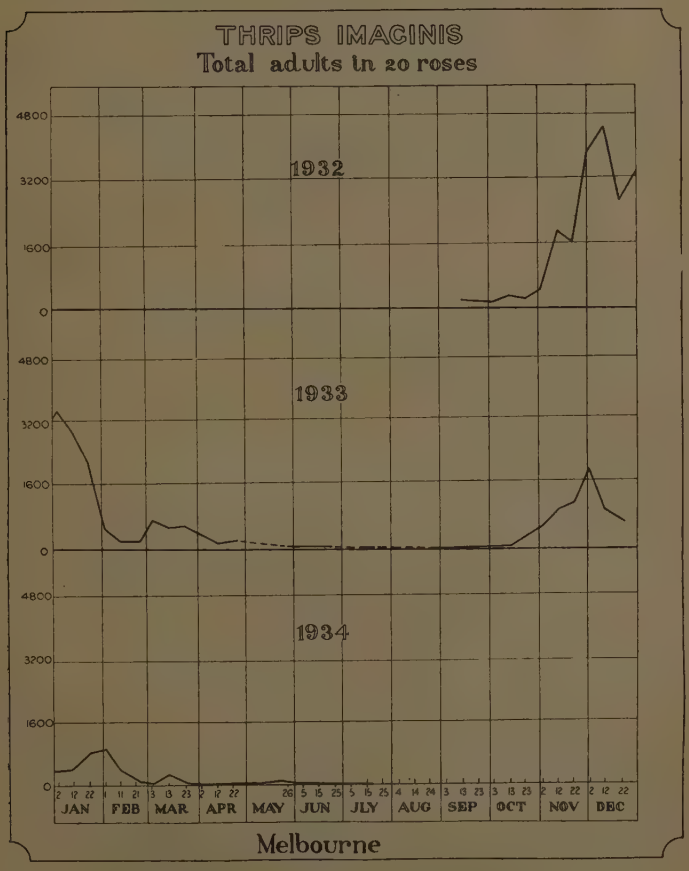

Fig. 1.—Showing fluctuations in the numbers of *Thrips imaginis* during period September 1932 to July 1934.

followed by a small increase in late autumn. During winter, the species is almost completely absent from flowers. The numbers of *T. imaginis* recorded from flowers during the latter period does not necessarily give a true picture of the actual numbers present during the winter; our observations indicate that, in the Melbourne district, this species overwinters in the adult stage; the temperatures during June, July, and early August are too low to induce the adults to seek out fresh situations; consequently, the insects are absent from flowers.

In certain years, the normal seasonal fluctuations in numbers of *T. imaginis* may be greatly modified owing to weather factors; the increase in numbers in the autumn may be relatively large, and the numbers in spring may become so large as to constitute a "plague."

In Figs. 2, 3, and 4, fluctuations in the numbers during certain periods are presented, together with particular factors in the physical environment of the insects which we consider are of major importance in regulating these seasonal fluctuations.

The most important factor operating against high numbers in summer and early autumn is low soil moisture. In Fig. 2, the numbers of thrips present during the summer and autumn of 1932-33 and 1933-34 respectively are shown. The ratio of rainfall to evaporation from a free water surface (R/E ratio) during these periods is also shown. This ratio serves to indicate the approximate soil moisture conditions; when the ratio remains above unity, the soil may be considered to be wet; when it remains below 0.5 for any considerable time, the soil can be considered to be too dry to support live thrips pupae except in local situations. In both the years under review, relatively high numbers of thrips were recorded early in the summer; these were reduced to very low numbers during late summer and in the autumn. It is significant that in each case the R/E ratio was below 0.5 for most of the late summer and early autumn. A fall of 135 points of rain on 3rd April, 1934, was probably responsible for the small rise in numbers which occurred towards the end of May, 1934.

In Fig. 3 the numbers of *T. imaginis* during the autumn of 1934 are shown, together with rainfall and mean air temperatures during this period. The numbers of thrips on 3rd April, when 135 points of rain fell, had reached a very low level as a result of the low soil moisture which had prevailed during the previous two months. After this date, the soil remained moist, and a small increase in the numbers of thrips occurred towards the end of May. A very sudden decrease occurred after 22nd May, which is probably explained by the pronounced drop in temperatures after this date. Temperature is the most important factor operating against the activity of the adults of *T. imaginis* during the winter; below 15° C. (59° F.), they become very sluggish; therefore, with the temperatures prevailing around Melbourne during winter, the adults are inactive, and do not seek out fresh flowers. The very pronounced drop in numbers between 22nd May and 1st June, 1934 (Fig. 3) can hardly be interpreted as due to heavy mortality during this period. It is considered that most of the adult individuals present in the flowers on 22nd May remained alive during the following June and July; they overwintered in an inactive state elsewhere than in flowers. The overwintering adults become active, and commence to reproduce, when temperatures rise in spring.

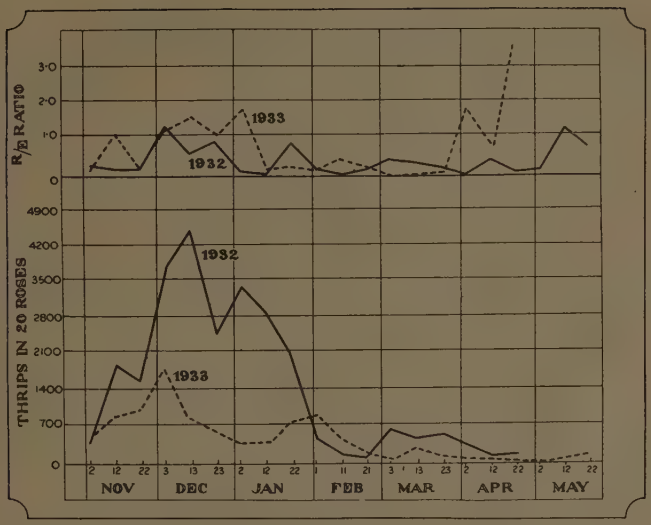

FIG. 2.—Showing numbers of *Thrips imaginis* present during summer 1932/33 and 1933/34; also the R/E ratio for the same period.

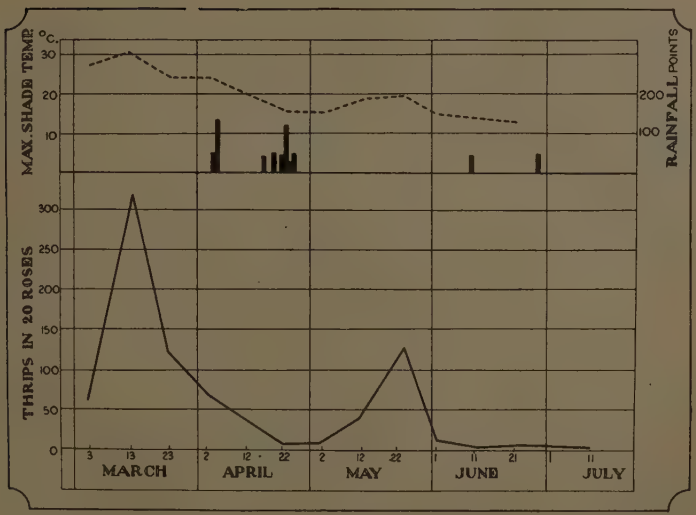

FIG. 3.—Showing numbers of *Thrips imaginis* present during autumn and winter 1934; also rainfall and mean maximum temperature.

In Fig. 4, the numbers of thrips occurring at the end of winter and during the spring of 1932 and 1933 are compared. Records for the autumn of 1933 and 1934 are shown in Figs. 1 and 3 respectively; records for the autumn of 1932 are not available.

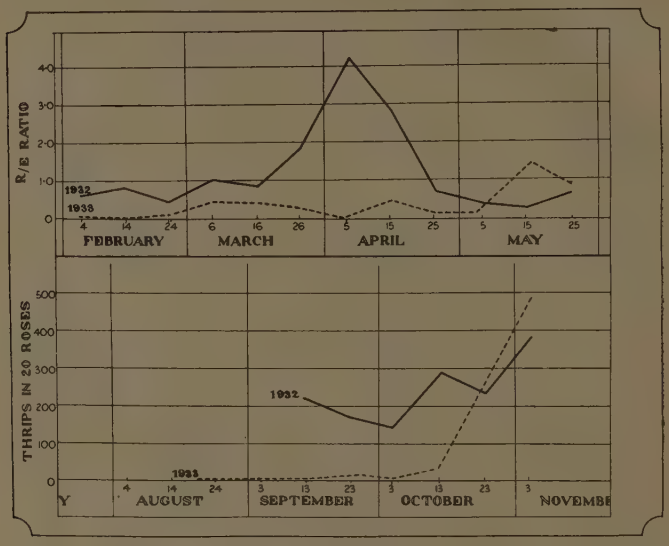

FIG. 4.—Showing numbers of *Thrips imaginis* during spring 1932 and 1933; also R/E ratio for the previous autumn.

The R/E ratios for the autumn periods of 1932 and 1933 are also shown in Fig. 4. It is seen from the values for R/E during 1932, that adequate soil moisture was probably maintained continuously from the middle of February onwards. In 1933, on the other hand, the R/E ratio stayed consistently below 0.5 until 15th April; this allowed only a short period during which soil moisture was favorable for the insects, before winter set in.

The influence of this difference in soil moisture during autumn is strikingly reflected in the numbers of thrips which developed in the subsequent early spring period in each year (Fig. 4).

4. Acknowledgment.

Our thanks are due to the officers of the Commonwealth Weather Bureau who have been most helpful with regard to the meteorological data used here. We also wish to thank Dr. J. Davidson for help and criticism, particularly with reference to the presentation of the data.

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Thrips Investigation.

5. On the Effect of Soil Moisture on the Viability of the Pupal Stages of *Thrips imaginis* Bagnall.

*By H. G. Andrewartha, M.Agr.Sc.**

(*From the School of Agriculture, University of Melbourne.*)

The work described in the following article forms part of the programme of the co-operative investigations on thrips under the arrangements referred to in the editorial to the previous paper (see page 234).—Ed.

Summary.

This experiment was designed to show the effect of soil moisture on the viability of the pupal stages of *Thrips imaginis*.

The thrips used were all taken from the same laboratory stock.

The soil used is described with respect to its mechanical analysis, sticky point, and "field capacity." There was a range of favorable soil moistures within which the viability of pupae did not vary; outside this range, the viability fell off rapidly. The limits of the favorable range were not materially affected by the temperatures used.

At points just outside the dry limit of the moisture range, the viability was higher at the higher temperature. Dry soils are possibly lethal because they compete with the pupae for moisture.

The larvae of *Thrips imaginis* exhibit a strong instinct to enter the soil to pupate, and they tend to obey this instinct even when it results in their destruction.

1. Introduction.

A study in the seasonal fluctuations in the number of *Thrips imaginis* in Victoria has shown that the insects are more abundant in years in which there are heavy, or moderately heavy, falls of rain early in the autumn; and that the high numbers normally present early in the summer fall rapidly as the dry period sets in. As Evans (1934) has pointed out, the eggs, being embedded in the tissues of plants, are not affected by high temperatures and low humidities; neither are the larvae† and adults, so long as they can replace their water losses by water taken in with the food; but the pupal stages, which are passed in the soil, are entirely dependent upon soil moisture to replace their water losses, and are thus the stages in the life cycle of the insect which are most subject to desiccation. On the other hand, there is no evidence to show that heavy rains are very harmful to larvae and adults, as thrips outbreaks have been known to follow years in which the winter rainfall was abnormally high. But, as will be shown later, excessive soil moisture can be fatal to the pupal stages in the soil.

2. Description of the Experiment.

Fourteen hundred larvae were used in this experiment; they were all taken from various generations of the same laboratory stock. This stock was started from about 50 adults of both sexes collected from roses in the field in March, 1934. They were all reared on rose buds (from which the petals had been removed) at a constant temperature

* An officer of the Council accommodated at the School of Agriculture, University of Melbourne.

† The term "larvae" is used rather than "nymphs" since with *Thrips*, the pupal stages are clearly defined.

of 23° C. (73.4° F.). Females were allowed one day in which to lay eggs, and were then removed from the cage. In this way, larvae which were all at approximately the same stage of development were obtained. At 23°C., the larvae are within one or two days of pupation on the seventh day after the eggs are laid.

The experiments were conducted in 100 c.c. beakers with plain tops. Soil which had been passed through a 2-m.m. sieve was made up to the required moisture content by adding water and mixing in an enamel basin. It was then placed in the beaker to a depth of 1 inch and shaken down by gently tapping the beaker on the bench. A rose bud from which the petals had been removed was put in each beaker, and 20 larvae were place on each bud. The beakers were covered by a piece of fine calico held in place by a rubber band. To avoid the possible influence of light on those individuals which pupated close to the glass, the lower half of each beaker was covered with black paper. After two days, the flowers were removed, and with them all the thrips which had pupated in the flowers and on the surface of the soil or on the walls of the container; only those individuals remained which had actually pupated within the body of the soil. The beakers were kept in desiccators over a 5 per cent. solution of sulphuric acid giving a relative humidity of about 97 per cent. Under these conditions, changes in the moisture content of the soil were very slow. The soil moisture was estimated accurately at the beginning and end of each experiment, by drying duplicate samples for twelve hours at 104°C. (219.2°F.). For each experiment (that is, for each soil moisture value), 100 larvae (divided into 5 lots of 20 each) were used. For the experiments at 14°C. (57.2°F.), the thrips were reared at 23°C., but were "acclimatised" by spending two days at 18°C. (64.4°F.) before being placed at 14°C.

At 23°C., the majority of adults emerged about 6 or 7 days after the larvae had been placed in the beakers; at 14°C., the peak emergence occurred on the 13th and 14th day. In each case, the experiment was continued for 2 clear days after the last adult had emerged.

The soil used was red loam having a mechanical analysis:—Fine sand = 36.30 per cent., coarse sand = 4.40 per cent., sticky point = 32.12 per cent.

In addition to these values, a further determination, which cannot be properly described by any of the terms in common usage, was made. The method of making the determination was as follows:—A wooden box 18 inches by 9 inches by 14 inches deep was filled with soil which had passed a 2-m.m. sieve; the soil was packed by gently tapping the box on the floor. The latter was immersed in water until free water was showing on the surface of the soil; it was then removed and allowed to drain, being covered by sacking to prevent loss of water by evaporation. The soil was sampled (disregarding the top inch) at daily intervals, and the moisture value recorded when the moisture in the soil had come to equilibrium; this occurred after the 3rd day. The moisture value was 39.7 per cent., calculated on the dry soil; it represented "the amount of water held in equilibrium against gravity" by the artificial soil which had been built up in the box, and can therefore be regarded as the "field capacity" of this artificial soil. The soil in the beakers really represented an artificial soil, corresponding closely in composition, texture, structure, and packing to the soil in the box. It is considered that the term "field capacity," determined

as here described, is the best "single value" factor to which to refer the various soil moistures used in the experiment; it is realized that the term should be properly restricted to soils in the field. It is probable that the "field capacity" of the artificial soil used in these experiments was higher than the true field capacity of the soil in the field from which it was taken. Veihmeyer and Hendrickson (1931) point out that the structure of the soil markedly influences its field capacity. West (1931) has shown that sticky point is a reliable index for field capacity. From West's conclusions, one would expect the true field capacity (in the field) of this soil to be about 32 per cent. to 35 per cent.

3. Discussion of the Results Obtained.

The experiments A–I were conducted at a constant temperature of 23°C. The results are shown in Table I. The sixth column gives the number of individuals which pupated below the surface of the soil, expressed as a percentage of the total larvae added to the beakers. Column seven gives the mean viability of the pupae as a percentage of the total larvae which pupated within the soil. Experiments K–P were carried out at 14°C.; the results are given in Table II. Only the value expressing the mean viability is given in Tables I. and II. In order to make the presentation of the data more complete, Table IV. has been included to show the 66 individual readings from which these means were calculated. All the experiments were taken together in an analysis of variance. The value of "z" was calculated from the formula:

$$Z = \tfrac{1}{2} \log_e \frac{S_1}{S_2}$$

where S_1 is the variance for experiments and S_2 the variance for error. For these experiments, z was found equal to 1.796. $n_1 = 13$, and $n_2 = 52$. From Fisher's (1930) table of z, it is seen that, when $n_1 = 12$ and $n_2 = 30$, a z of 0.5224 lies on the .01 level of probability, and hence it follows that there is significant difference between the experiments in this group.

Several of the experiments were then compared in pairs (see Table III.). The values of P given in the table were obtained from Fisher's (1930) table of "t." The difference between any pair of experiments may be regarded as significant when P does not exceed 0.05.

Table I.—23°C.

Experiment.	Soil Moisture as Percentage of Dry Soil.			Mean Soil Moisture as Percentage of "Field Capacity."	Larvae to Enter Soil.	Viability of Pupae.
	Beginning.	End.	Mean.			
	%	%	%	%	%	%
A.	7·5	7·9	7·7	19·2	66	1·2
B.	8·5	8·7	8·6	21·5	67	45·6
C.	10·6	9·7	10·2	25·5	96	81·0
D.	15·6	14·2	14·9	37·2	100	93·7
E.	27·9	25·6	26·8	67·0	96	90·7
F.	30·6	28·1	29·4	73·5	100	93·7
G.	34·8	33·6	34·2	85·5	100	90·0
H.	37·4	36·2	36·8	92·0	83	66·2
I.	44·3	43·2	42·2	105·5	80	9·0

TABLE II.—14°C.

Experiment.	Soil Moisture as Percentage of Dry Soil.			Mean Soil Moisture as Percentage of "Field Capacity."	Larvae to Enter Soil.	Viability of Pupae.
	Beginning.	End.	Mean.			
	%	%	%	%	%	%
K.	8·8	8·4	8·6	21·5	82	2·4
L.	9·2	8·6	8·9	22·3	78	23·6
M.	11·4	9·9	10·6	24·9	96	70·4
N.	27·4	25·5	26·4	66·2	98	89·8
P.	34·6	31·3	32·9	82·4	97	76·0

TABLE III.

Experiments.	P.
A.–B.	Less than ·01
B.–C.	Less than ·01
G.–H.	Less than ·01
H.–I.	Less than ·01
C.–D.	Between ·1 and ·05
C.–M.	Between ·5 and ·4
G.–P.	Between ·3 and ·2
B.–L.	Between ·05 and ·02
B.–K.	Less than ·01

TABLE IV.

Viability of Pupae as a Percentage.

Pot No.	Experiment.													
	A.	B.	C.	D.	E.	F.	G.	H.	I.	K.	L.	M.	N.	P.
I. ..	0	27	72	90	78	85	80	50	0	0	12	30	79	42
II. ..	0	40	74	90	90	95	85	56	0	0	13	61	85	74
III. ..	0	56	75	95	95	95	90	69	0	0	29	77	90	75
IV. ..	0	60	84	100	100	100	95	73	12	6	31	89	95	89
V. ..	6	..	100	..	..	..	100	83	33	6	33	95	100	100
Mean ..	1·2	45·6	81·0	93·7	90·7	93·7	90·0	66·2	9·0	2·4	23·6	70·4	89·8	76·0

At 23°C., in soils having a water content ranging between 25.5 per cent. and 85.5 per cent. of the "field capacity" value, the viability of the pupae varied between 81 per cent. and 94 per cent., and the differences were not significant in any example. There was a significant drop from 81 per cent. to 45 per cent. viability when the soil moisture fell from 25.5 per cent. to 21.5 per cent.; and a drop from 45 per cent. to 1 per cent. associated with a reduction in soil moisture from 21.5 per cent. to 19.2 per cent. of the "field capacity" value. Similarly, the viability fell from 90 per cent. to 66 per cent. when the water increased from 85.5 per cent. to 92 per cent.; and from 66 per cent. to 9 per cent. as the soil moisture increased from 92 per cent. to 105.5 per cent. of the

"field capacity." It is apparent that at 23°C., with this soil, there was a range of favorable soil moisture. The limiting values were respectively about 25 per cent. and 85 per cent. of "field capacity." Above and below these values, the viability fell off very rapidly (see Fig. 1); the fall was slightly more abrupt at the dry end than at the wet end of the range.

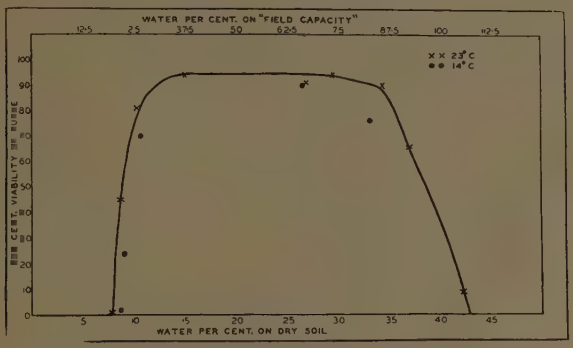

FIG. 1.—Showing relation between soil moisture and viability of the pupal stages of *Thrips imaginis*.

Results of approximately the same order were obtained at 14°C. (Table II.); the points obtained at this temperature fall fairly close to the curve drawn through the points for 23°C. It is of interest to examine the results at the two temperatures where the soil moisture was comparable. In no instance were the soil moisture values identical at the two temperatures, but in some instances they were sufficiently close to make comparisons valuable. Where the soil moisture fell within the favorable range, there was no significant difference in the viability of the pupae (compare experiments C and M, E and N, and G and P). From the similarity in the results of experiments C and M, it may be concluded that the dry limit of the favorable range is about the same for each temperature (and possibly for all temperatures). There is no evidence from these experiments as to the relative position of the wet limit to the favorable range at the two temperatures, but it is probable that it is about the same for each temperature. There was a significantly higher viability in experiment B than in either K or L, notwithstanding the fact that the soil was somewhat moister in L than in B. This would suggest that at points just outside the dry limit of the favorable range there is a higher survival at the higher temperature owing to development being more rapid.

It is probable that in an excessively wet soil the pupae are killed simply by drowning and asphyxiation. But it is not quite clear how a dry soil operates to bring about their death. It is obvious that there must be competition between the pupa and the soil for moisture, and it is possible that the soil actually withdraws moisture from the pupa. Whether this competition is concerned with water in its gaseous or its liquid phase is not quite clear. In this connexion, it would be interesting to know whether the dry limit of the optimum range bears any relationship to the "wilting point" of the soil. Veihmeyer and

Hendrickson (1934) have pointed out that the ratio of moisture equivalent to wilting point varies from 1.4 to 3.8, and that both high and low ratios were obtained from both sandy and clay soils. Hence, it is not possible to give a reliable estimate of the wilting point of this soil. It is plain, however, that with soils in which the moisture content is below the dry limit of the favorable range, there is a competition between the pupa and the soil for water in some form or another. Since, at points just outside the favorable range, on the dry side, there is a higher survival at the higher temperature, it would seem that the soil's competition for water does not increase as rapidly with increasing temperatures as does the speed of development of the pupa.

The observations of Evans (1934) agree, in the main, with results given here. When the soil moisture was below 25 per cent. of his "saturation value" at the beginning of the experiment, very few adults came through. It is not quite clear, from his data, whether there was any significant difference between the first three rows of his table; and it may be that by wetting the soil on the 5th and 6th day respectively he was merely postponing the time when the soil dried out below the limit of the favorable range, thus allowing the more tardy individuals to complete their pupal development.

Another fact of interest emerges from this experiment. It will be seen from column six of Tables I. and II. that, of the 800 larvae placed over soil within the favorable moisture range, only 17 failed to go below the surface of the soil to pupate. When the soil moisture was less favorable, the proportion was not so great, but even in experiment A, where the soil moisture was such that only 1 per cent. of the pupae survived, 66 per cent. of the larvae went below the surface to pupate. Similarly in experiments I and K, where the viability was 9 per cent. and 2 per cent. respectively, 80 per cent. and 82 per cent. of the larvae entered the soil to pupate. It is apparent from these figures that *Thrips imaginis* larvae have a strong instinct to go below the surface of the soil to pupate, and that they tend to obey this instinct even though it results in their destruction.

4. Acknowledgments.

The writer is much indebted to Mr. G. Leeper and Mr. T. J. Marshall for advice and assistance in matters pertaining to soil moisture; to Miss A. Nicholls, who made the determination of the mechanical analysis; and to Mr. J. Freedman, who made the sticky point determination for him. He also wishes to thank Dr. J. Davidson for advice and helpful criticism in the preparation of this paper, and Miss F. E. Allen for advice and assistance in the statistical analysis of the data.

5. References.

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The Use of an Electric Moisture Meter for Testing Veneers.

*By W. L. Greenhill, B.E.**

The use of the steel blades ordinarily employed as electrodes when testing the moisture content of timber with an electrical moisture meter becomes impracticable when the specimen to be tested is less than about ¼ inch in thickness, as the timber splits, and satisfactory contact between the timber and the blades cannot be obtained. In addition, the marks made by the blades might be undesirable in a surface veneer.

Preliminary investigations of the possibility of using an electrical moisture meter to test veneer sheets by clamping the sheets between plate electrodes gave promising results. Following this, a design was prepared for an attachment to be used with sheets of commercial size, and this was subsequently constructed. To test its application, veneers of various thicknesses of Douglas fir, Queensland walnut, and New South Wales coachwood were used.

The results, which are reported below, show that the instrument can be used satisfactorily provided certain precautions are taken.

1. Apparatus.

The special attachment for clamping the veneers between plate electrodes is illustrated in the diagram (Fig. 1). The general idea should be apparent from the sketch. The electrodes used are of brass and 3 inches in diameter. The pressure necessary on the handle to ensure consistent results is in the vicinity of 70 lb., and for this reason the attachment should be set up on a rigid table at the correct height to enable the operator to exert this pressure without undue effort. An adjustable catch holds the electrodes together while the Blinker reading is taken. The catch is adjusted for various thicknesses of veneer, and automatically comes into operation when the necessary pressure is exerted. It is released by a trigger on the handle after the reading is taken, and the electrodes are separated by a spring.

2. General Procedure.

The main calibration tests were made with Douglas fir, as this is the species with which the Division's standard Blinker electrical moisture meter is calibrated, and it was considered that if "electrode" correction figures were obtained for this species, these correction figures could be applied to any species, together with the normal species correction. In this way, the necessity for carrying out tests with veneers of different species could be avoided.

Sufficient material was available to enable 20 Douglas fir veneer test pieces of the 3-16-in., ⅛-in., and 1-32-in. thicknesses, 11 pieces of the 1-16-in. thickness, and 6 pieces of the 1-10-in. thickness to be brought to equilibrium in conditioning boxes to each of the approximate moisture contents, 8 per cent., 10 per cent., 12 per cent., 14 per cent., and 18 per cent. These pieces were then tested for moisture content by clamping them in the special device which was connected to an ordinary Blinker.

* Officer-in-charge, Section of Timber Physics, Division of Forest Products, C.S.I.R.

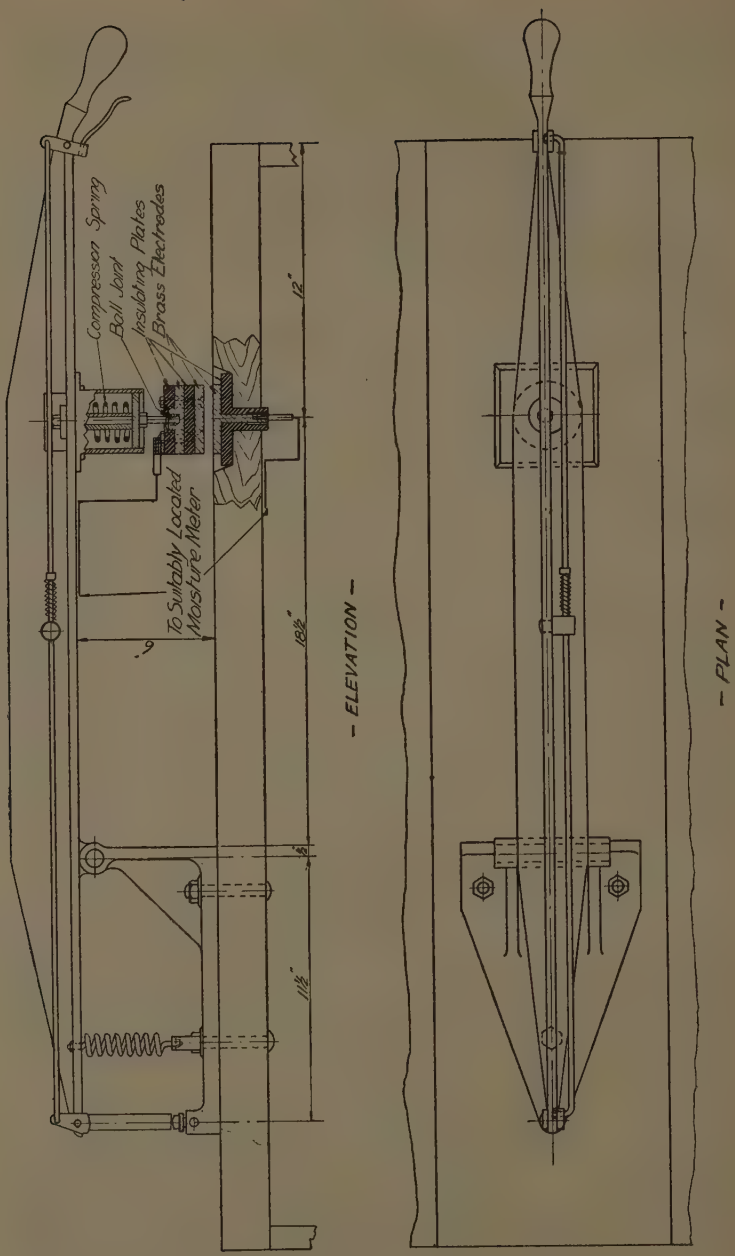


FIG. 4.—Electrodes for use when testing veneer sheets.

In addition to these, tests were made at moisture contents of approximately 8 per cent. and 10 per cent. on six samples of each thickness, using the same samples at the two moisture contents. The actual moisture contents were obtained by oven-drying.

From the figures so obtained, correction curves were drawn for each thickness of veneer.

Three samples of coachwood and Queensland walnut of each of the thicknesses available were later tested at moisture contents of approximately 9 per cent. and 12 per cent., and the Blinker readings obtained corrected for species as well as for the special electrodes. Check moisture contents were obtained by oven-drying.

3. Results.

The results of the tests on the Douglas fir samples are shown on the graphs in Fig. 2, which give the corrections which must be made on account of the special plate electrodes used. The actual points from which these curves were drawn are not shown on account of the congestion which would result. These points, although occasionally falling as far as 2 per cent. from their corresponding curves, were reasonably well grouped, and enabled the curves to be drawn without trouble. In many cases, where the discrepancies were large, the reason could be traced to either checked samples, or to the fact that the samples had been too loosely held between the electrodes. Both these causes of erroneous results must be carefully guarded against when testing veneer in this way. Errors are also introduced if the electrodes come too close to the edge of the veneer. To be quite safe, this distance should be not less than ½ inch.

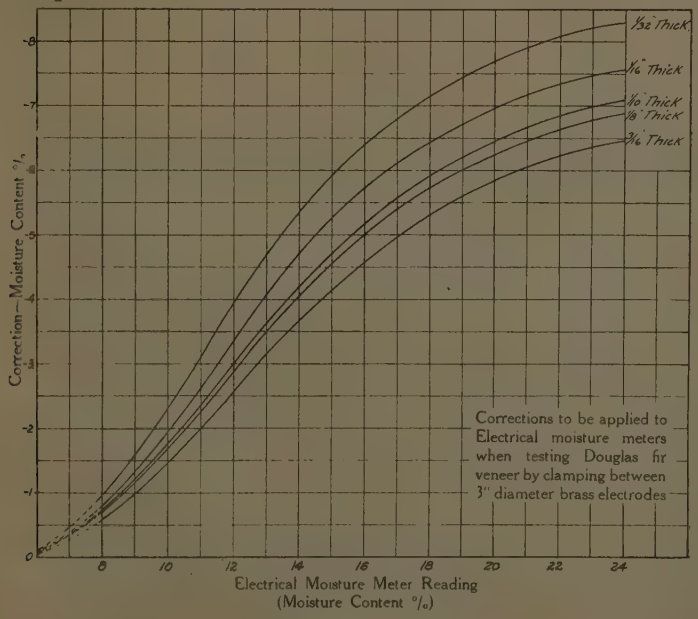


Fig. 2.

The results obtained with the Queensland walnut and coachwood samples are given in the following table:—

Species.	Thickness.	Actual Blinker Reading.	Electrode Correction (to nearest ½ per cent.).	Species Correcton (to nearest ½ per cent.).	Corrected Blinker Reading.	Moisture Content by Oven-drying.
	Inches.		%	%		%
Coachwood ..	·060	20	− 7	0	13	12½
	·050	19	− 7	0	12	12
	·033	19	− 7½	0	11½	12
Queensland Walnut	·050	14	− 5	+ 1	10	11
	·035	17	− 6½	+ 1	11½	11½
Coachwood ..	·060	14½	− 5	0	9½	9½
	·050	14	− 5	0	9	9½
	·033	13	− 4½	0	8½	9½
Queensland Walnut ..	·050	9	− 1½	+ 1	8½	9
	·035	11½	− 3½	+ 1	9	9

These results serve to indicate that, provided the necessary precautions are taken, the special veneer attachment can be used to give results for veneer sheets to the same degree of accuracy as is obtained with the hammer electrodes on thicker timber.

One important point to be noted is that the actual range of the Blinker is reduced from 8%–24% to about 7%–17%. At the lower end of the range, the resistance increases so rapidly with fall in moisture content that any attempts to extend the range below 7 per cent. using the veneer electrodes will meet the same difficulties that are met in attempting to extend the normal range of the Blinker below this reading.

FIG. 1.—Cross bending fracture of a specimen of karri (*E. diversicolor*), showing sudden change from heart to truewood, as indicated by the brittle and fibrous fracture

FIG. 2.—Side and end views of typical fractures of heart and truewood specimens. Note the characteristic "carrotty" fracture of heart.

FIG. 1.—General appearance of broken fibres as isolated from brittle wood near centre of tree. Note distinct breaks at right angles to the long axis of the fibres. × 95.

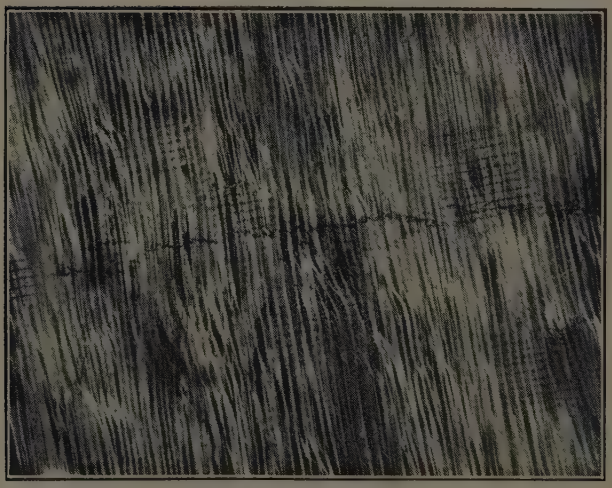


FIG. 2.—Minute compression failure in cell walls of *E. gigantea* × 95. (Under polarized light.)

NOTES.

Troubles Concerning the Storage and Transport of Eggs.

(i) "*Watery Whites.*"—An egg that is defective on account of "watery white" can readily be distinguished on candling. Loose air bubbles are seen in the white, and the air space is rather larger than normal. "Watery white" is a defect that is fairly widespread, and has been the subject of investigation in several countries. A report recently received from Northern Ireland indicated that the condition may arise in consequence of packing eggs with the broad end down.

However, there is reason to believe that this cause is not the only one, and a little time back the Egg Producers' Council of Australia requested the Council (C.S.I.R.) to undertake a study of the condition as it occurred in Australia, and offered £100 as a contribution towards the cost of the work.

The matter was discussed at a meeting of the Standing Committee on Agriculture, held in February, 1934. The Committee requested the Council to organize an investigation in co-operation with the States. Shortly afterwards, the co-operation of the South Australian Department of Agriculture was obtained, and a programme of investigation is now in progress. This programme was suggested by Mr. C. F. Anderson, Poultry Expert of the South Australian Department, and is being supervised by him. Three of the main poultry districts most subject to the trouble have been selected for the work, and the assistance of leading poultrymen in each district has been enlisted. The eggs from the farms of these producers are being tested throughout the year, taking into consideration the ages of the birds from which they were secured. The eggs are to be tested both on the farm and later on the Adelaide packing floors. A number of commercial breeds and strains of poultry will be tested to ascertain whether some breeds or strains are more liable to the trouble than others. The effects of different foods on the various breeds on each of the selected farms will also be determined, and some special feeding trials will be made at the Parafield Poultry Station.

In addition to the above co-operative programme, the New South Wales Department of Agriculture is also carrying out some tests with eggs from its Grafton Experiment Farm. This work has been completed for the winter months, and will be repeated during the coming summer months.

(ii) *Green Yolks.*—In one or two of the southern States of Australia, trouble is experienced at times with green yolks of eggs. Individual producers occasionally lose up to 40 per cent. of their total production. The problem has been investigated in other countries, where it has been found that it is sometimes due to the fowls consuming certain varieties of green fodder. A preliminary test of that theory in Australian cases has failed to reveal any fodders that are causing the trouble.

The problem was discussed at the September meeting of the Standing Committee on Agriculture, when it was arranged that Mr. H. R. Marston, of the Council's Division of Animal Nutrition, would inquire into the matter in collaboration with State officers.

Meeting of Standing Committee on Agriculture.

A meeting of the Standing Committee on Agriculture (which was established some years ago with a view to the co-ordination of agricultural research throughout Australia), was held in Melbourne on the 27th and 28th September. On this occasion, Dr. J. H. Cumpston (Director-General, Department of Health), and Mr. J. F. Murphy (Assistant Secretary, Department of Commerce) also attended. They had been invited to be present in view of the Government's desire to extend the scope of the Committee. Some of the matters discussed are mentioned in the following paragraphs.

Address by Minister.—The Minister in charge of the Council (Senator the Hon. A. J. McLachlan) briefly addressed the meeting, and expressed his appreciation of the successful way in which the Committee had operated, since its formation in 1927, as a means of developing a truly national spirit in scientific research work for the benefit of Australian agriculture. After explaining the desire of the Government that the status of the Committee should be improved, he concluded his address by a mention of the Australian citrus industry as one requiring all the assistance scientific methods could afford, particularly in regard to the production of fruit of the required quality for export.

Standing Committee—Proposals for Increasing its Status and Extending its Sphere of Usefulness.—A considerable amount of time was devoted to a consideration of this matter. The Committee was unanimously of the opinion that it was desirable for the Committee to be accorded increased status, and to be accepted as a national body designed (i) to secure co-operation and co-ordination in agricultural research throughout the Commonwealth; (ii) to advise the Commonwealth and State Governments on matters pertaining to the initiation and development of agricultural research on problems which are of a national character; (iii) to secure co-operation between the Commonwealth and States, and between the States themselves with respect to quarantine measures relating to pests and diseases of plants and animals, and to advise the Commonwealth and State Governments with respect thereto.

The Committee also agreed that an appropriate name for the new body would be "The Australian Council for Agriculture," and that its personnel might appropriately be the permanent heads of the State Departments of Agriculture, the Director-General of Health, the Secretary of the Department of Commerce, and the members of the Executive Committee of the Council for Scientific and Industrial Research.

Introduction of Plant Diseases with Imported Seed.—This matter is discussed elsewhere (see page 254).

Uniform Seed Standards and Methods of Testing.—Arrangements were made to hold a conference of State and Federal officers at an early date with a view to bringing about uniformity in the standards of purity of commercial seeds, and also in the methods of testing such seeds.

Standardization of Common Names of Grasses and Legumes.—Dr. B. T. Dickson reported that, in accordance with a previous decision of the Committee, nearly 500 species of grasses and clovers had been given suggested standardized common names. These suggestions are now being circulated among the authorities concerned. The criteria taken into consideration when suggesting a common name for adoption were that

the name should be descriptive and simple, that it should indicate the relationship of the plant, that the name in most common use should be retained, and that, where an introduced species had a more recognized name in its country of origin, it should be retained.

Tobacco.—This matter is discussed elsewhere (see page 252).

Standardization of Primary Products and Wearing Parts of Agricultural Machinery.—Both these matters had been referred to the Standards Association of Australia at a previous meeting. Progress was reported.

Weeds.—Arising out of the Committee's consideration of the weed problem, it was arranged that a small working committee would be established in each State, and charged with the duty of exercising a general oversight of weeds investigations in its State. These Committees will be representative of the States and of the Council for Scientific and Industrial Research, and, it is hoped, will facilitate an orderly attack on the problem from a national point of view.

Rusts in Wheat—Barberry Bush.—This matter is discussed elsewhere (see page 252).

Butter Industry.—A considerable amount of discussion was devoted to the question of protecting the butter industry against butter substitutes, and also to the need for improving the general quality of Australian butters. It was pointed out that the industry is at the moment seriously menaced as a result of the development of methods of producing margarine from vegetable fats, and resembling high-grade butter so closely that it is difficult for householders to detect the difference.

Virus Diseases of Potatoes.—Dr. Dickson reported that, in accordance with a decision at a previous meeting, he and Mr. Magee (New South Wales Department of Agriculture) had met on several occasions, and were collecting information concerning this problem. It appeared that the losses potato-growers suffered by virus diseases were probably much greater than had previously been thought. It was arranged that the actual diseases would be studied at Canberra, and that suspected tubers would be sent to that place from the various States.

Egg Problems.—This matter is discussed elsewhere (see page 249).

Preservation and Transport of Foodstuffs.—The Committee decided that it would be well if the Council for Scientific and Industrial Research acted as the channel through which the British Food Investigation Board might be advised of all experimental shipments of fruit to Great Britain. In the past, the results of the Board's examinations of various experimental shipments have at times been reduced in value by the lack of knowledge of the history of the fruit in Australia.

It was also considered desirable for an officer having an expert knowledge of food storage diseases to be stationed at Australia House to report on the state of commercial shipments reaching the British market.

Codlin Moth.—It was arranged that a Committee, representative of the States and the Council for Scientific and Industrial Research, should be formed to look into the position of codlin moth control, and to make recommendations to the next meeting.

Next Meeting.—The next meeting of the Committee will, it is hoped, be held in Brisbane in April, 1935, at which time the State Ministers of Agriculture will probably meet.

Rusts in Wheat—The Danger of the Common Barberry Bush.

At the September meeting of the Standing Commitee on Agriculture, attention was drawn by the representative of the New South Wales Department of Agriculture (Mr. G. D. Ross) to the danger to the wheat industry caused by the common barberry bush, which is rather widely grown in Australia as an ornamental shrub.

It has been found that hybrid strains of rust can easily develop on the bush, and that some of these are so virulent that they can affect varieties of wheat previously considered to be immune. In the United States of America, millions of dollars have already been spent on eradicating the common barberry. Apparently, it is only one variety of barberry that is dangerous, namely, *Berberis vulgaris*. Other varieties that are widely grown, e.g., *thunbergii*, are immune to rust.

It was agreed that it was desirable to look into the whole position, and it was arranged that at the next meeting the State Departments of Agriculture would report on the extent of the occurrence of the common barberry within their borders, and also on the measures that had been taken to encourage growers to eradicate it.

Fuller details of the nature of the menace are given in the *Agricultural Gazette of New South Wales*, October, 1934, page 545.

Tobacco Investigations.

At the September meeting of the Standing Committee on Agriculture, the representatives of the Council and of the State Departments of Agriculture reported the progress their respective organizations had made under the scheme whereby the Commonwealth Government has agreed to provide £20,000 per annum for research and demonstrational work aimed at the benefit of the tobacco industry (see this *Journal*, May, 1934, page 120, since the appearance of which note the Government has agreed to extend the scheme over a period of five years instead of three). The main substance of these reports was as follows:—

(i) *Work of the Council for Scientific and Industrial Research.*—As regards blue mould, consideration is being given to the possibilities of developing methods of control based on spraying and such like processes, despite the possibilities of using disease-free seed as a means of overcoming the trouble. At Wangaratta (Victoria), tests of two sprays recommended by the Queensland Department of Agriculture, together with tests of Bordeaux mixture and one or two other sprays, are in progress. At Ashford (N.S.W.), in co-operation with the State Department of Agriculture, tests of the Bathurst method of raising healthy seedlings are being carried out, and the method is under investigation with a view to ascertaining precisely why seedlings treated do not develop mould. Some spraying tests are also in progress at Ashford and at Deniliquin (N.S.W.). Studies are also being made in regard to the seasonal behaviour of epidemics of blue mould. At Canberra, a number of crossings between various species of *Nicotiana* are being made in order to ascertain whether it is possible to develop strains resistant to blue mould or leaf spot and yet producing good quality leaf. A triple hybrid from Russia is also being

studied. Tests are also in progress with a view to ascertaining whether manufacturing methods can be modified so as to improve the smoking qualities of Australian tobaccos. In addition, various smoking tests and modifications of the usual curing processes are in progress. At the University of Sydney, Professor Earl is directing a chemical investigation of leaf in the hope that the results may give a lead to methods of improving quality.

(ii) *Work of State Departments of Agriculture.*—In New South Wales, a small experimental station has been established at Ashford where variety trials and manurial tests have been put in hand, together with a demonstration of the Bathurst method of blue mould control. Two additional officers have been appointed, one to visit tobacco districts in an advisory capacity, and the other to take charge of the work at Ashford. In Victoria, two field assistants and one other officer have been appointed and provided with transport facilities. Two experimental plots, one at Myrtleford and one at Pomonal, have already been established. In South Australia, a tobacco instructor has been appointed and experimental plots have been established with a view, *inter alia,* to ascertaining whether good quality leaf can be produced on the Upper Murray Irrigation Areas. In Queensland, four officers have been appointed and some twenty experimental plots established. In Western Australia, two officers have been appointed, one for advisory work and the other more particularly for experimental work.

Cumbungi (*Typha latifolia*)—Notes on its Commercial Value.

Some time ago, the New South Wales Water Conservation and Irrigation Commission and the Victorian State Rivers and Water Supply Commission asked the Council for advice as to methods of eradicating a species of reed (*Typha latifolia*), known locally as "cumbungi," the growth of which was causing considerable concern in connexion with the work of keeping irrigation channels clear.

Inquiries which were made by the Council indicated that the problem of exterminating the weed by any cheap and effective method was likely to be very difficult, particularly since it would be impracticable to use poisons which might cause trouble when the water reached the areas to be irrigated. As it appeared to be impossible to indicate any direct and simple method which was likely to be successful, and at the same time economically practicable, it was decided to explore the possibilities of utilizing the fibre of the weed for industrial purposes. It had been suggested that as cumbungi appeared to have a particularly tough fibre it might be used for the manufacture of rope and cordage or baskets, mats, &c.

As the Imperial Institute at London had already had considerable experience in examining materials of the nature in question, a sample of *Typha latifolia* was sent to that Institute with a request for a preliminary investigation to be made as to its commercial value. The Institute complied with that request, and the Director (Lt.-Gen. Sir William Furse, K.C.B.) has been good enough to furnish a report on the results of the examinations which were made.

The fibre obtained from the reeds after treatment was rather coarse, weak and brittle, and it was not found possible to extract fine strands of any considerable length. The tests showed that the reeds are not likely to be of practical value as a source of fibre for cordage or textiles. They also showed that, whilst fairly good paper can be made from them, the yield of pulp of a quality suitable for paper-making is low, so that from a commercial point of view the prospects of employing the material for that purpose are not promising.

Sir William Furse pointed out that a considerable amount of experimental work had previously been carried out at the Imperial Institute and elsewhere on the paper-making possibilities of *Typha* reeds of various species, but that the results had shown that in general they are not promising as sources of paper pulp. It seemed likely that the reeds might be more suitable for the manufacture of strawboards and boxboards, as the tests by the Imperial Institute showed that a high yield of pulp of suitable quality for board-making could be obtained under mild conditions of treatment. It appears, however, that the cost of freight and other economic conditions in Australia are such that it is not likely that the reeds could be used profitably for the manufacture of boards in this country.

Imports of Vegetable Seeds into Australia in relation to some Plant Diseases.

At the meeting of the Standing Committee on Agriculture, which was held in Melbourne on the 27th and 28th September, the question of the danger of the introduction of certain plant diseases into Australia per medium of seed, particularly vegetable seed, was raised.

Several fungous, bacterial, and virus diseases affecting tomatoes are known to occur in Australia. Several others, while occurring in other countries, have not yet been met with in Australia. Some of those which do occur, however, are particularly serious to the glass-house product.

Although it is impossible to state definitely whether the tomato spotted wilt virus, which is rather widespread in various States of the Commonwealth, is endemic, or whether it was introduced, it seems reasonable to assume that it came into Australia with seed or vegetable parts of ornamental plants, as the virus is known to have a particularly wide host range.

Virus diseases may occasionally be introduced by means of the seed, and it is possible that "streak," which has recently been recorded in Australia, became established in this way.

With modern methods of extraction of tomato seeds, without the intervention of a fermentation process, there is now a much greater risk of the distribution of bacterial parasites on the surface of the seed, and accordingly further commercial importations of such seed must expose Australia to greater risks than was previously the case. Particularly is this so when it is considered that it has been demonstrated that certain virus diseases of tomatoes may be carried internally in the seed; prevention of outbreaks of such diseases by quarantine measures is correspondingly difficult.

The cucumber and related plants, such as melons, pumpkins, &c., are also subject to several seed-borne diseases, some of which are not yet known in Australia. Examples of such diseases are the angular leaf spot of the cucumber caused by *Bacterium lachrymans,* the blight caused by the fungus *Macrosporium cucumerinum,* and the scab caused by the fungus *Cladosporium cucumerinum.*

The lettuce, the cabbage, the cauliflower, Swede turnips, carrots, parsnips, celery, sweet corn, and onions are also subject to various seed-borne diseases, some of which are not yet known in Australia.

Various ways of obviating the danger of diseases arising from imported seeds have been suggested. One such is that growers in Australia be encouraged to use seed that is produced in Australia. It has also been suggested that, after the lapse of a reasonable time, no more seed be allowed to be imported.

It was arranged by the Standing Committee that the whole matter of vegetable seed-borne diseases should be considered by a small Committee representative of the State Departments of Agriculture and of the Commonwealth Department of Health (which is responsible for plant quarantine in Australia).

An Aerial Photographic Survey of the Mildura (Vic.) and Wentworth (N.S.W.) Districts.

A set of twenty-four mosaics comprising a complete aerial photograph of the settlements of Mildura, Red Cliffs, Merbein (Victoria), Curlwaa and Coomealla (New South Wales), has been received from the Air Board as a result of the work in November, 1933, of the photographic section of the R.A.A.F. The work involved was carried out on behalf of the Council's Division of Soils, which will shortly commence a detailed survey of the areas.

Some 300 square miles have been covered by the photographs, which embrace the oldest and newest irrigation settlements in the Murray valley, and clearly define the 35,000 acres of horticultural development, and its relation to the river flats, on the one hand, and the virgin mallee on the other. While most of the settled area has reached an approximate maximum of expansion, the Coomealla section provides scope for considerable extension, and the whole of this adjacent virgin land has been photographed. The mosaics have been pieced to include as far as possible all or the bulk of the individual settlements on separate sheets. The ground scale of the finished mosiacs is 6 inches to 1 mile. Previous experience has shown this to be a satisfactory working scale as far as requisite clearness of detail is concerned. On the horticultural areas, the disposition of the planting, the exact definition of the uncultivated land, the topographic features (with the aid of a stereoscope), as well as the extent and degree to which plantings are affected by salt accumulation or other troubles, are all readily discernible on inspection The photographs will, consequently, be of considerable assistance during the progress of the soil survey.

The present series of photographs of Mildura and Wentworth districts is the third photographic survey in the Murray valley carried out for the Division of Soils by the R.A.A.F., the previous cases being the Renmark and the Berri-Cobdogla Irrigation Areas in South Australia.

An Experimental Kiln for Air-Flow Investigations.

(Contributed by W. L. Greenhill, B.E.)

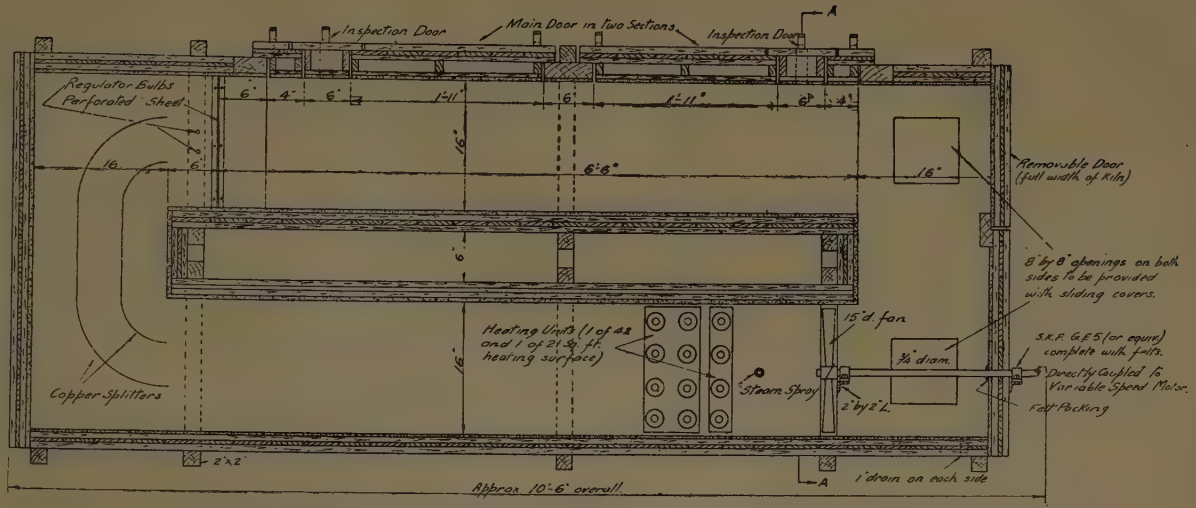
Timber seasoning kilns employing forced circulation are now recognized to be by far the most satisfactory types for the great majority of purposes. From the point of view of air circulation, however, a number of factors in the design must still be contributed more as a matter of guesswork than as the result of experimentally established facts. In many cases, preventable waste doubtless occurs, due to the desire to err on the safe side in the design of those particular items, while in other cases it is probable that efficiency is being sacrificed because of cramped space or insufficient air circulation.

A number of the factors affecting the air circulation can be determined only in commercial kilns; these factors refer mostly to the proportions of the kilns. The more fundamental problems can be readily investigated in an experimental kiln. These problems relate to the establishment of a satisfactory commercially applicable method of measuring the rate of air flow, to the determination of the resistance to air flow through a stack of timber, to the investigation of the effect of different rates of air flow on the rates of drying of various species of timber and the degrade during drying, and to the design of fans for the purpose of circulating the air.

With the object of investigating these and similar problems, a special experimental kiln has been built at the laboratory of the Division of Forest Products. This kiln is shown in section in the accompanying figure. It is constructed of three thicknesses of timber, covered inside with ½-in. insulating board, and lined with copper. Each side was built separately, and then assembled with packing at the joints, and held in place by steel straps and rods. At the lower right-hand corner is a propeller type fan, which is directly coupled to a variable speed motor. The air from the fan passes over the heating units along the lower chamber, and is delivered through the metal splitters, which serve to promote more uniform flow to the upper chamber with less friction loss. At the entrance to this chamber a perforated metal plate further serves to even out the air distribution in the chamber.

Large doors fitted with small inspection doors provide access to the top chamber in which timber stacks up to 6 feet in width can be constructed. After passing through the stack, the air is either returned to the fan, or passed directly out through the end of the chamber, according to the particular test in hand.

Ventilation openings and a steam spray are provided. The kiln is fitted with an automatic temperature and humidity recorder controller for maintaining any desired conditions within the kiln. Auxiliary equipment used includes a special anemometer, thermocouples and potentiometer, pitot tubes, and a micro-manometer.



Experimental Kiln for Air Flow Investigation.

Timber Seasoning Classes.

As part of its programme of assisting the timber industry in improving the practice of timber seasoning, it has been the custom of the Division of Forest Products to conduct short classes in this subject from time to time.

At the first such class, held in Melbourne in 1930, there was an attendance of 13, consisting mainly of students from the Victorian Forestry School and officers of the Tasmanian Forest Service. Two years later, at the second Melbourne class, there was an attendance of 28, mostly drawn from the Victorian timber industry. Similarly well attended classes have since been conducted in Tasmania, and a third Melbourne class was planned for the last week of September, 1934. For this, 60 applications were received, necessitating the holding of two separate classes, in order that those attending might receive as much individual attention as possible. The second portion of the class was held during the first week of October.

This marked increase in attendance is an indication of the increased interest in improving practice in timber seasoning, and is a very gratifying reward for the efforts of the Division of Forest Products in this direction.

Recent Publications of the Council.

Since the last issue of this *Journal,* the following publications of the Council have been issued:—

Bulletin No. 82.—"The Insect Inhabitants of Carrion: A Study in Animal Ecology," by Mary E. Fuller, B.Sc.

To solve any problem, it is necessary first to understand the nature of the problem, so fundamental research must generally precede the devising of methods of controlling pests. The plan of blowfly research of the Council's Division of Economic Entomology has provided for two main fundamental investigations, namely, an ecological study to discover the precise relations of blowflies to their environment, and an equally precise study of the factors that influence the susceptibility of sheep to blowfly strike. The fact that biological control was an important part of the Division's policy was an added reason for making the ecological investigation the first main line of research, for only by accurate comparative ecological work can one recognize whether a natural enemy is likely to be useful or not. The results of the ecological investigations undertaken at Canberra are set out in this Bulletin. The outstanding result brought out is that competition between the larvae is the main factor regulating the general blowfly population in Australia. The numbers of adults of any one species present in the field are more than sufficient to provide any carcass with many times the number of larvae which it can support, whilst actually there are several species occupying and sharing it. Consequently, there is intense competition between the larvae for food and space. Various other factors which might reduce the intensity of this competition are discussed, but there is no evidence that these factors ever reduce the blowflies to a point at which competition no longer occurs, and so become themselves the primary influence on blowfly abundance. The normal succession of primary, secondary, and tertiary insects which inhabit carrion at different stages are discussed at length.

Bulletin No. 83.—"Natural Pastures: Their Response to Superphosphate." by J. Griffiths Davies, B.Sc., Ph.D., A. E. Scott, M.Sc., and K. M. Fraser, M.Agr.Sc.

The Bulletin contains a report on the co-operative investigations into the mineral deficiencies of pastures which are in progress at the Waite Agricultural Research Institute, and which were initiated some years ago by the former Empire Marketing Board, the Waite Institute, and the Council for Scientific and Industrial Research, in co-operation. The investigations discussed in the Bulletin were instituted with a view to ascertaining the effect of phosphatic fertilizers on the carrying capacity, the nutritive value, and the mineral content of natural pastures in the better rainfall areas of South Australia. Investigations were conducted at two centres, the more detailed ones at the Waite Institute, and the less detailed at the Kybybolite Experimental Farm. At the Waite Institute, annual applications of 2 cwt. of superphosphate per acre resulted in an increase of 67 per cent. in the yield of hay, and the number of sheep wholly maintained on the top-dressed pasture was 60 per cent. greater than the untreated paddocks, but no important differences were observed in the weight of fleece per sheep maintained on the differently treated paddocks. The increased return of wool per acre was thus entirely the result of the increased number of sheep carried. The seasonal changes in the composition of the pastures were investigated, and it was found that fibre increased from a minimum value of 17 per cent. in winter to a maximum of approximately 40 per cent. in autumn. The protein varied inversely as the fibre. The feeding of phosphatic lick supplement on a natural pasture did not affect any increase in the carrying capacity per acre, in the live weight of the sheep, or in the yield of wool per sheep. Neither the superphosphate top-dressing nor the supplementary phosphatic lick had any influence on the proportion of scoured wool in the fleece or on the count, handle, or style of the individual fleeces. The results obtained at Kybybolite were largely confirmatory of the results at the Institute.

Pamphlet No. 48.—"Field Observations on Weather Stain and Blowfly Strike of Sheep, with Special Reference to Body Strike," by F. G. Holdaway, Ph.D., and C. R. Mulhearn, B.V.Sc.

This publication concerns blowfly strike in sheep from the point of view of the bacterial conditions of the wool known collectively as "weather stain." The results discussed were obtained after visits to various sheep stations in New South Wales, and after a study of some 13,000 sheep. Various conclusions are given concerning the relation of the colour of the wool yolk to stain and strike. Wool density as a factor in susceptibility is shown to be related to sweat concentration.

Pamphlet No. 49.—"Some Important Poison Plants of North Australia," compiled by the Poison Plants Committee.

This Pamphlet has been compiled by various members of the Poison Plants Committee, which for some time past has been investigating suspected poison plants, samples of which have been forwarded to it from a number of places in Australia. The Pamphlet discusses a few of the common poison plants, chiefly of the northern areas, in a brief and simple fashion, with the idea of enabling the stockman and drover to recognize those plants which are poisonous, and where possible to

avoid them with live-stock. It was also prepared with the idea of giving him some information concerning the poisonous properties of the various plants, so as to enable him to put together cause and effect when mortality occurs. Drawings are given of each plant discussed; these are the native fuchsia or spotted Berrigan; flat spurge, red soldier, milk weed, caustic weed; tree or wild tobacco, tobacco bush; native tobacco; desert poison bush or wallflower poison bush; poison sage; ironwood; rattlepods or pop pods; New Holland rattle pod; caustic bush or caustic vine; double-seeded emu poison bush; Ellangowan poison bush or dogwood poison bush; narrow-leaved sage or wild mint; Pan-Jada or bastard indigo; Flinders River poison; Georgina gidgee; bovine indigo.

Forthcoming Publications of the Council.

At the present time the following future publications of the Council are in the press:—

Bulletin No. .—"Radio Research Board Report, No. 6." 1. On the Plane of Polarization of Long Radio Waves. 2. A Field Intensity Set. 3. Measurements of Attenuation, Fading, and Interference in South-eastern Australia at 200 kilocycles per second.

Bulletin No. .—"Radio Research Board Report, No. 7." The Propagation of Medium Radio Waves in the Ionosphere. 2. The Characteristics of Downcoming Radio Waves. 3. The Influence of Electric Waves in the Ionosphere. 4. Long Distance Observations of Radio Waves of Medium Frequencies.

Bulletin No. 84.—"The Basal (Standard) Metabolism of the Australian Merino Sheep.—II.: Factors Affecting the Basal Metabolism," by A. W. Pierce, B.Sc.

Bulletin No. .—"Studies on the Phosphorus Requirements of Sheep.—II. The Effect of Supplying Phosphatic Supplements to Growing Lambs Depastured on Phosphorus-deficient Country," by H. R. Marston, E. W. Lines, B.Sc., T. J. Marshall, M.Agr. Sc., and J. S. Hosking, B.Sc

Bulletin No. .—"A Soil Survey of the Berri, Cobdogla, Kingston, and Moorook Irrigation Areas, and of the Lyrup Village Settlement, South Australia," by T. J. Marshall, M.Agr. Sc., and P. D. Hooper.

Pamphlet No. 50.—"The Design of Overhead Irrigation Systems," by E. S. West, B.Sc., M.Sc., and A Howard, M.Sc.

Pamphlet No. .—"Thrips Investigation: Some Common Thysanoptera in Australia," by H. Vevers Steele, B.Agr.Sc., M.Sc.

Pamphlet No. .—"Australian *Hamitermes* (Isoptera), with Descriptions of New Species and Hitherto Undescribed Castes," by G. F. Hill.

Pamphlet No. .—"The Chemistry of Australian Timbers. Part 4, A Study of the Lignin Determination II.," by W. E. Cohen, B.Sc.